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From a mural painting by Arthur Covey

Corner of a Piece-Goods Dye House.

EDITOR'S OUTLOOK

The Frontispiece

WE TAKE this opportunity of acknowledging the courtesy of the National Aniline and Chemical Co., Inc., in lending us the photograph from which this month's frontispiece cut was prepared. The original is one of a series of murals by Arthur Covey in which are depicted various processes in the manufacture and application of dyes.

John Jacob Bausch

THE past month witnessed the death of a man whose name, at least, has been familiar to scientific educators for many years. John Jacob Bausch was, strictly speaking, neither a scientist nor an educator, yet the company which he founded has undeniably been an influence in the development of both science and education in this country.

The story of his life constitutes one of those "poverty-to-riches" dramas, so dear to the American public. With his material success we are not greatly concerned. The indomitable courage of the man, his imperturbability in the face of adversity, and his energy are, however, worthy of recording, entirely aside from the tangible rewards with which they met. These qualities, together with the skill which he had acquired as an apprentice in the optical instrument business in Germany and Switzerland, were practically his only assets when he landed in New York, in 1849, at the age of nineteen.

During his early months in America, spent in Buffalo, he learned the wood-working trade in a furniture factory and it was as a wood-worker that he first found employment in Rochester when he finally went there. Within a few months he made his first venture into the optical business, but unsuccessfully and was forced to return to wood-working. At this trade he soon became an expert workman but, losing two fingers in a buzz-saw accident, he was compelled for a period to remain idle and, when he returned to work, found himself so handicapped that he decided to again attempt to enter the optical field.

Finding the imported lenses which he sold to be of rather inferior quality, Mr. Bausch built a small lense-grinding machine and began to produce his own lenses—the first ground in America. So marked was the superiority of his product that other opticians soon sought to obtain his surplus.

It was at about this time that he obtained a small loan from Henry Lomb and in return promised to take his creditor into partnership if the business should ever warrant such a step. This was soon done but the

business did not prosper greatly until Mr. Bausch conceived the idea of moulding eyeglass frames from hard rubber. Even then growth was very gradual, although the firm began to branch out into many lines.

Before the war Mr. Bausch had realized the weakness of the American optical industry in its dependence on German glass and had inaugurated research with a view to remedying the situation. When the outbreak of the war made the production of American optical glass imperative, the United States Government chose to conduct its researches in coöperation with the Bausch & Lomb laboratories. Our readers will recall the account of the successful prosecution of this problem which was made public in connection with the Court of Chemical Achievements' exhibit at the last Exposition of Chemical Industries.

Mr. Bausch had always taken a keen interest in charity and in civic affairs, although of late years the infirmities of age had somewhat curtailed his personal activities. His death is sincerely mourned by the entire city of Rochester and by his friends and business associates throughout the country.

Prolonging the Educational Period

WE ARE gratified to learn, through news notes in the educational and chemical press and through private communications, of the number of institutions which are now offering evening courses in chemistry. These courses are for the most part designed to meet the needs of men employed in chemical industries who desire to extend their chemical training or to obtain advanced degrees. Some of them are also directed toward the accommodation of teachers who feel the need of further study in their chosen field. This practical acknowledgment of the theoretically conceded principle that education is a life process rather than a childish thing to be put aside at commencement day is an encouraging development.

It is not our implication that education need necessarily be carried on within university walls. Too many obvious examples arise on every side to refute any such contention. On the other hand we do not believe that the university has fulfilled all its potentialities for service to the community when it distributes its diplomas to successive classes of bachelors, masters, and doctors and turns them forth to shift for themselves. The exceptional individual will, it is true, take up the responsibility which his *alma mater* has relinquished and carry on in defiance of all discouragement. The average man, however, finds it difficult to plan and adhere to a schedule of study when his resolution is not fortified by the necessity of attendance at classes and the preparation of assignments. Even the resolute and self-reliant individual cannot but find the organi-

zation of subject-matter and the comments, explanations, suggestions, and occasional corrections of a good teacher an invaluable aid.

We are not unmindful of the oft-reiterated warning that there can be no royal road to learning but neither do we believe that there is any great virtue in laboriously surmounting obstacles which could as well be removed or evaded. Nor does it appear to us altogether just to regard disparagingly the man who seeks to reënforce his resolution with external props. Rather let him be credited with the discernment to realize his limitations and the wit to make provision for them.

Domestic Exchange

NOT long ago we commented in these columns upon the exchange of professors between American and foreign universities and pointed out a few of the benefits which should arise from a more general adoption of the practice. We believe that similar advantages would attach to the extension of the exchange system among American universities themselves.

Many institutions have established outstanding reputations for work in particular fields in chemistry, and number among their faculty members men of national and international fame. Clearly it would be to the interest of a student to take courses at a number of noted universities and this plan is followed to some extent in graduate work. Unfortunately, however, the average undergraduate student cannot pursue his education in the itinerary fashion which was so much in vogue in Europe a few centuries ago.

Doubtless the privilege of studying under notable teachers is not the only benefit to be derived from varying the scene of one's educational endeavors. It is, however, one benefit which could be extended to numerous students who have no opportunity to travel even within their own country. A quarter's, semester's, or even a year's exchange of professors between American universities should be easily arrangeable and would involve but inconsiderable expense. Surely the profit to the contracting institutions and to their students would far outweigh the minor difficulties to be encountered.

Nor need the exchange system be confined to professors of established reputation alone. Quite frequently an instructor has planned some special piece of work which, because of necessary laboratory facilities or geographical or other considerations, can be more satisfactorily executed at some other institution than his own. If an exchange can be arranged the projected work is brought to completion, each of the professors involved carries to the institution which he visits a fresh viewpoint and a

new mode of presentation of the subjects which he teaches and receives in turn new ideas and suggestions which cannot but improve his subsequent work.

Better Positions for Better Teachers

IN ORDER to facilitate proceedings at the initial meeting of the Senate of Chemical Education at Tulsa, Senators were requested to submit suggestions as to projects for consideration. The replies were numerous and covered a wide range of subjects—so wide a range that it would be impossible to attempt a discussion of all or most of them at any single meeting. Accordingly, the suggestions received were grouped under eight major heads and in this form were again submitted to the members of the Senate with a request that they be numbered in the order of their supposed urgency.

The only item which ranked preponderately ahead of the others was that which related to the better training of chemistry teachers. Apparently no one realizes more clearly the desirability of elevating the standards of the profession than do the teachers themselves.

A number appended the comment that efforts to improve teaching personnel should be accompanied by an attempt to convince administrators of the advisability of offering properly qualified teachers more attractive conditions of employment as to salary, opportunity for further study, etc. We believe the point to be well-taken. No one desires to see any body of scientists or educators adopt the spirit or the aims of a labor union, nor do we believe these suggestions are offered in any such mood. Aside from the entirely just and proper proposition that where greater value is demanded, greater reward should be offered, there exists the simple economic fact that goods and services as a rule tend to gravitate toward the best markets. True, many teachers continue in their chosen profession in disregard of more attractive outside offers, yet, even for him who is a teacher at heart, there often comes a time when the margin of difference is too great to be reasonably ignored. More particularly is this so with the younger teachers just entering the profession.

Unless, then, we can, while training teachers more thoroughly, maintain within the profession a market for their services which shall not compare too unfavorably with that of the industries, we shall but defeat our own purpose. The superior teacher is generally an exceptional man in other respects and, as such, a man in demand in other fields. Better teachers without better working conditions can mean but one thing—greater temptations to leave the profession.

THE CHEMISTRY OF RUBBER

W. J. KELLY AND H. A. BRUSON, RESEARCH LABORATORIES, THE GOODYEAR TIRE & RUBBER COMPANY, AKRON, OHIO

Although rubber is obtained from the latex of several hundred different trees and shrubs, the most important and best rubber is obtained from the *Hevea Braziliensis*. This tree was originally found in the valley of the Amazon but has since been transplanted and cultivated in the Far East until the rubber produced on the plantations comprises over 90 per cent of the world's production. Brazil, which formerly held the commanding position, has been reduced almost to insignificance as far as rubber production is concerned. The following table shows the growth of the plantation industry since 1900.

TABLE I. WORLD PRODUCTION OF RUBBER IN LONG TONS

Year	Plantations	Brazil	Others	Total	% Plantation	% Brazil
1900	4	26,750	27,136	53,890	0.008	49.7
1905	145	35,000	27,000	62,145	.24	56.4
1910	8,200	40,800	21,500	70,500	11.6	53.0
1915	107,867	37,220	13,615	158,702	68.1	23.4
1920	304,816	30,790	8,125	343,731	88.7	8.9
1923	384,771	22,580	5,420	412,771	93.1	5.5

The rubber from the *Hevea* tree being, therefore, the most important commercially, has been the subject of more researches than any of the others and this is especially true since the plantations started producing such a large percentage of the world's supply. In this paper we shall deal exclusively with the chemistry and physics of the rubber from this tree.

The Physical Chemistry of Rubber

Latex.—The latex of the *Hevea* tree is a white fluid which looks very much like ordinary milk. In the tree it is contained in canals located in the bark just outside of the central woody portion of the trunk, roots, and branches. The real physiological function of the latex is at present unknown as is the method by which the rubber is formed in it.

To obtain the latex the bark is cut, and the milky fluid runs out and is led to the base of the tree where it is collected in cups. The yield from any tree depends on several factors: age, girth, fertilization, etc., but will average about 10 to 12 grams of dry rubber per day.[1] Thus, in order to produce enough rubber to satisfy the world's demand, it is obvious that an enormous number of trees has to be cultivated.

As it issues from the tree, the latex is neutral or faintly alkaline and statements in the literature vary as to its actual p_H value. It slowly turns acid on exposure to the atmosphere and natural coagulation sets in.

When viewed under the microscope the latex is seen to consist of many small particles suspended in an aqueous medium and all in rapid Brownian

movement. These particles vary in size from about 0.5μ to 3.5μ and are mostly pear- or egg-shaped. Some of them have decided tails on the small end. Besides the Brownian movement these particles also exhibit a rotary motion. This motion is not confined to any axis and is probably due to the same cause as the Brownian movement.

Besides these particles there are several other substances in the latex and Table II, from "Estate Rubber" by O. de Vries (p. 14), will give a fair idea of the composition of the latex.

TABLE II. COMPOSITION OF LATEX AND RUBBER

	Latex, %	Dry Rubber, %
Rubber Hydrocarbon	28	92-94
Commercial Rubber	30	100
Total Solids	33-34	98.8-99.7
Ash	0.3-0.7	0.15-0.45
Nitrogenous Matter (Proteins)	1-2	2.5 -3.5
Components Soluble in Acetone	about 2	2.5 -3.2
Quebrachite	1-2	?
Reducing Sugars	0.15-0.35	?

The part played by these non-rubber substances is not completely known at present and neither is their distribution in the latex. The nature of the protein is likewise not completely known.

More work has been done on the resins than on the other constituents and it has been shown that these consist to a large extent of fatty acids, principally stearic, oleic, and linolic.

All of the substances which are found in the dry rubber are essential to vulcanization, especially the fatty acids.

Structure of the Latex Particle.—Freundlich and Hauser[2] have recently shown that the latex particle consists of three distinct parts. The center is a highly viscous hydrocarbon easily soluble in benzol. This is surrounded by a shell of another hydrocarbon probably a polymer of higher molecular weight than the interior. It is much more viscous, perhaps nearly solid, and not so readily soluble in benzol. On the outside of this is a second shell of non-rubber substance, probably mostly protein. The determination of the structure of the individual particle of the latex was a big step forward in explaining the behavior of rubber. It has been suggested many times that rubber is not a simple substance but a two-phase system. The work of Freundlich and Hauser is a proof of the presence of two hydrocarbon phases along with the protein shell. The importance of this proof will be evident later, as it will be used to explain many of the phenomena hitherto incapable of explanation.

Coagulation of Latex.—There are many substances which will cause the latex to coagulate and separate the rubber from the serum. Cataphoretic

measurements have shown that the latex particles are negatively charged. They should thus be coagulated by hydrogen ions and the polyvalent cations. The most widely used substance is acetic acid, which yields the best grade of plantation rubber. Other acids and also salts have been used in experimental work but no substance has yet been found which yields as good a product as acetic acid. This method is used almost exclusively on the plantations, whereas the wild rubber from Brazil is coagulated on paddles in the smoke of a fire.

The theories on coagulation by natural processes or chemical agents are many. Some authorities hold that it is caused by an enzyme whose ac-

FIG. 1.—Gathering Latex. This picture shows the method of cutting the bark for tapping, and the general layout of the plantation. Photograph taken on the Goodyear Tire & Rubber Company's plantation in Sumatra.

tivity is increased by the hydrogen and other ions. Others consider it due to bacteria which convert the sugars present to acids and thus discharge the particles.

Freundlich and Hauser (*loc. cit.*) show, however, that it is most probably due to a coagulation of the protein present in the latex. This protein plays a very important role in rubber and it is evident from the literature that whatever affects the protein so as to weaken it, also affects the rubber produced in the same way. The removal of the protein by digestion with trypsin completely inhibits the coagulation of the rubber to a firm clot and simply results in a cream which can be redispersed in the serum. Further

study of the coagulation from this viewpoint is essential to the complete explanation of the process.

The coagulation of fresh latex is not an instantaneous process. After the addition of the acid the latex gradually becomes more and more viscous and finally sets to a gel which includes the entire liquid of the system. Syneresis then sets in and the water is expressed, carrying with it the soluble salts and inorganic substances. The rubber floats on top as a firm coagulum which is then further purified by washing with water to remove any serum or soluble substances.

Unlike the coagulation of many proteins, the coagulation of rubber is irreversible. Although methods of redispersing rubber in water are known, these do not return the system to its original state.

If the coagulation of rubber from the latex is due to the coagulation of the protein shell and other protein matter suspended in the latex then the resulting rubber is a network of protein enclosing the two hydrocarbon phases with the resins, etc., distributed between them. In other words, it is a dispersion of a large amount of hydrocarbon in a small amount of protein.

Action of Solvents on the Dry Coagulum.—When rubber which has not been subjected to any mechanical working after coagulation is placed in a solvent such as benzol, chloroform, gasoline, etc., it swells. If a light naphtha is used the rubber can be separated easily into two fractions as shown by Caspari.[3] Lately Feuchter[4] has repeated and enlarged Caspari's work and comes to the conclusion that rubber is a gel composed of two parts, one of which, probably the rubber hydrocarbon, can diffuse away from the other which he calls the "gel skeleton." The diffused portion is very elastic and sticky whereas the gel skeleton which still contains a large portion of hydrocarbon, is a brown, horny mass having little elasticity. If, however, the rubber is first broken down by mechanical working on a mill it does not swell appreciably but disperses readily and completely in the solvent. In the benzol sol or perhaps more properly the gel of the unmilled rubber, it is easy to see that there is a structure of some kind, whereas in the milled rubber sol no such structure is visible. That such is the case can be shown by measurements of the flow through capillary tubes. One to two per cent sols of milled rubber are viscous and obey Poiseuille's Law whereas those of the unmilled rubber do not. That the structure of the rubber can be broken progressively is shown by the facts that a 5 per cent sol of rubber milled for three minutes at 90° does not obey Poiseuille's Law and is, therefore, plastic; a 50 per cent (by volume) sol of rubber which was milled at about 40°C. for twenty minutes is viscous. The study of rubber sols from this viewpoint is not yet completed but it is expected that the results will go a long way towards

explaining some of the phenomena exhibited by rubber, especially when considered in the light of the work of Freundlich and Hauser.

Effect of Milling.—When rubber is worked mechanically on a mill it becomes progressively softer. The degree of softness which it attains depends on the length of time and temperature at which it is milled. Measurements of the plasticity of rubber after different times of milling have shown the following results.

Milling at high temperature (100°) does not produce as soft a rubber as

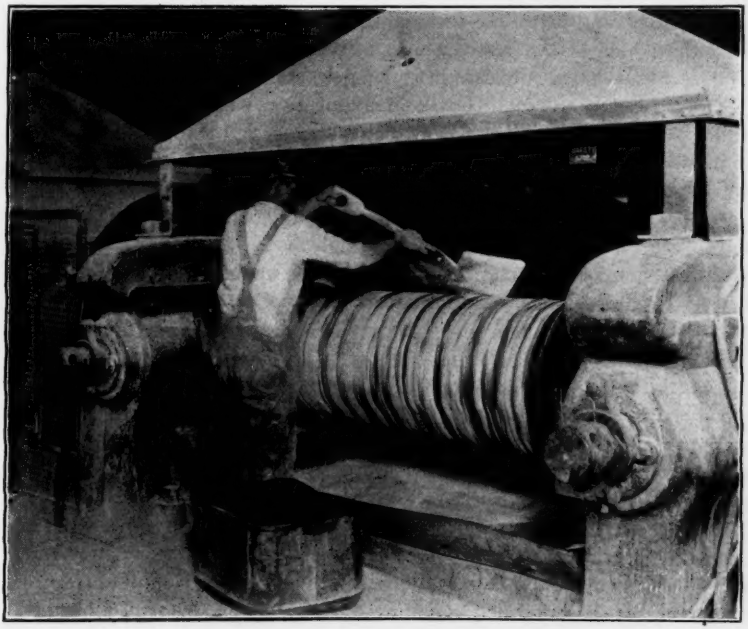


FIG. 2.—In huge mills of this type the crude rubber is milled and mixed with compounds before it goes to the calenders where it is united with the cord fabric out of which tires are made. The man is adding a white-colored compound to the batch, which may be distinguished on the huge roll as the black substance. Photograph taken in the mill room of the Goodyear Tire & Rubber Company's plant at Akron, O.

milling at low temperatures (40°). At any temperature, continued milling reduces the rubber to a certain degree of softness after which it remains constant. A reduction in temperature will further increase the softness until another constant value is reached. These facts may all be easily explained on the basis of the structure of the latex particle, as given by Freundlich and Hauser, as follows:

The particles of the latex do not break on coagulation but retain their

identity in the dried rubber. As soon, however, as this rubber is subjected to mechanical action some of the particles break, thus permitting the escape of the internal liquid. This liquid, having a comparatively low viscosity, is readily dispersed in the rest of the mass and softens it. This action continues until a sufficient number of these globules have been broken so that the viscosity of the mass is reduced to the point where the shearing action set up by the milling is not great enough to break any more globules. The plasticity of the rubber will then remain constant as long as the milling temperature is not reduced. If this temperature is reduced the viscosity, and hence the internal friction, of the mass is increased. As a result the shearing forces are also increased and more particles break. This continues until equilibrium is again established.

Thus, it is easy to explain how cold milling gives a softer rubber than hot milling, a fact that could not be explained on the old theory that the heat of milling depolymerized the rubber molecule. It would be expected that depolymerization would proceed faster at the higher temperatures, thus resulting in a softer stock than when milling was carried out at lower temperatures. If this were the case it might be expected that long storage at lower temperatures might cause an increase in the hardness of the rubber but Williams[5] has shown that there is no change in the plasticity over long periods of time.

Vulcanization.—The action of sulfur on rubber which was discovered by Goodyear in 1839 has yet to be explained. The first studies on this reaction were made by Weber[6] who came to the conclusion that the changes in the properties of rubber as vulcanization proceeded were due to the formation of a series of compounds. However, the fact that no mathematical relationship between the amount of sulfur combined with the rubber and the physical properties of the product could be found led subsequent investigators to look for other explanations. Wo. Ostwald[7] attempted to prove from some of the published literature that the process was not a chemical one but that it could be explained completely on the assumption that rubber adsorbed the sulfur. This theory found little favor among rubber chemists because of the fact that it is impossible to remove the combined sulfur from the rubber without destroying the rubber. Likewise, if vulcanized rubber be treated with chlorine, bromine, hydrogen chloride, or other agents capable of adding to a double bond, the resulting product always contains all the sulfur originally present in the vulcanized rubber. This could hardly be explained on the basis of adsorption.

In the past, investigators of this problem have endeavored to explain the action of sulfur by considering the rubber hydrocarbon alone. The introduction of organic accelerators turned the chemists generally to the study of their reactions in rubber and sulfur mixtures and finally lead to the

opinion that whatever the specific action might be, all accelerators produced an active form, probably atomic, of sulfur which acted more rapidly on the double bonds thus giving shorter times of vulcanization. The fact that these accelerators gave physically superior products with less combined sulfur is almost proof that the reaction between sulfur and rubber is only a small part of what actually takes place during vulcanization. Furthermore, if rubber is first extracted with acetone and then vulcanized it will be found that the rate of combination between the sulfur and rubber is the same as in the unextracted rubber but the physical qualities of the former are so inferior as to render the product useless. It is fairly evident, then, that the resins and other acetone-soluble material are essential to the vulcanization if a product with satisfactory physical properties is to be obtained.

If we consider the structure of rubber it is evident that there is an enormous interfacial area and, as the resin acids and organic accelerators are of the type which have a high surface or interfacial activity, it is within the bounds of possibility that the physical changes in vulcanization can be explained on the basis of interfacial relationships, combined with the change in the physical properties of the rubber hydrocarbon due to its reaction with sulfur. A study of the vulcanization process from this standpoint will have to be made within a very short time.

X-Ray Spectrograms of Rubber.—Lately some very interesting observations have been made by Katz[8] on the X-ray spectrograms of rubber. Ordinary rubber in the unstretched condition gives only the so-called amorphous rings. On stretching, a diffraction pattern begins to form which becomes more intense as the stretching is increased to 600 or 700 per cent elongation. There is no difference in the patterns at say 300 per cent and 700 per cent elongation except that the latter are more intense. Katz interprets this phenomenon as a crystallization or the formation of pseudo-crystalline-amorphous particles, all being oriented in the direction of stretching. The X-ray diagrams show that there is a fibrous structure in the stretched rubber and Hock[9] has shown by freezing and breaking a piece of stretched rubber that there is such a fibrous structure.

These results are very interesting but at present a sufficient amount of work has not been done to permit drawing final conclusions. It is probable that many of the perplexing questions pertaining to rubber will be answered by this new weapon of attack and all rubber chemists are waiting anxiously for more results.

The Organic Chemistry of Rubber

As has been stated previously the rubber as it is made on the plantations is not a pure substance and although the accompanying materials are es-

sential to the production of satisfactory goods, the nature of all of these materials has not been definitely determined. Ordinary rubber contains about 94 to 95 per cent of rubber hydrocarbon, the remainder being made up of two principal parts, the acetone-soluble portion and the insoluble portion which is probably mostly protein.

The acetone-soluble portion, as has been previously mentioned, contains a large percentage of fatty acids and also some higher alcohols (notably phytosterol) and two sterol esters. There is also present a small amount of a water-soluble, sugar-like crystalline compound, *l*-methyl inositol, commonly called quebrachitol.

The protein material can be obtained by filtering it from a dilute solution of rubber in chloroform, precipitating the rubber with alcohol, dissolving in chloroform and refiltering. These operations must be repeated three or four times before the protein is entirely removed. The protein is a fibrous material which dries to an amorphous brittle mass. It differs from most vegetable proteins in that it is quite stable. On hydrolysis it yields a mixture of mono-amino carboxylic acids, aromatic amino acids, tryptophane, and cystin.

There is also a small quantity of inorganic salts present in the rubber. These come from the serum and their function is unknown at present.

Preparation of Chemically Pure Rubber Hydrocarbon.—For purposes of chemical investigation raw rubber must be treated so as to remove all resins, proteins, etc. The rubber is first washed and then thoroughly extracted with acetone. This removes all water-soluble material and the so-called resins. To remove the proteins the extracted rubber is dissolved in benzol, filtered, and precipitated with acetone or alcohol. This process is repeated several times and the final product dried *in vacuo* at 100°C. At all stages of preparation it is necessary to protect the rubber from oxidation. The product is transparent, tough and elastic, of a light cream to tan color and shows no definite melting point. Its empirical formula is $(C_5H_8)_x$. On exposure to air it takes up oxygen slowly. It is easily dispersed in such solvents as benzol, chloroform, carbon tetrachloride, gasoline, carbon disulfide, etc.

Molecular Weight.—Many attempts[10] have been made to determine the molecular weight of rubber, but these have led to widely varying results. Some authorities place it at about 3000, while others claim that it is as high as 6000. This uncertainty is due to the fact that the temperature changes in the cryoscopic or ebullioscopic methods are exceedingly small as is the case with all colloidal solutions. Some investigators believe that the molecular weight of rubber is identical with the weight of a particle in the solvent employed and that this is a function of tem-

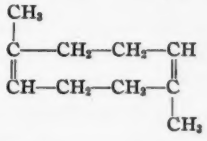
perature and concentration. It thus appears to vary between very wide limits. The minimum molecular weight shown by rubber in any of its derivations is 136 corresponding to $C_{10}H_{16}$. This figure was obtained from the freezing point of an acetic acid solution of the diozonide. The same compound in benzol gives a figure about two and a half times as great.

Pyrogenetic Decomposition.—When rubber is destructively distilled a liquid distillate is obtained which contains principally isoprene, C_5H_8, di-pentene, $C_{10}H_{16}$, and higher polyterpenes, all of which are polymers of C_5H_8.

Bouchardt[11] showed that, by heating, the isoprene fraction could be polymerized to a rubber-like mass. Tilden[12] and Wallach[13] obtained rubber-like products from the isoprene by treating it chemically, thus proving that the rubber hydrocarbon is a polymer of isoprene. Final proof of this was obtained by Harries from his work on the ozonides.

Action of Ozone on Rubber. Structural Formulas.—By treating rubber with ozone, Harries showed that two molecules of ozone add to every $C_{10}H_{16}$ group forming a di-ozonide, $C_{10}H_{16}O_6$.[14] When treated with water this ozonide splits up, yielding a mixture containing laevulinic aldehyde, $CH_3—CO—CH_2—CH_2—CHO$, laevulinic acid and small amounts of formic and succinic acids as well as carbon dioxide. Since ozone adds quantitatively to the double bonds in unsaturated compounds, the simplest formula for rubber would be an eight-carbon ring as shown in (1),

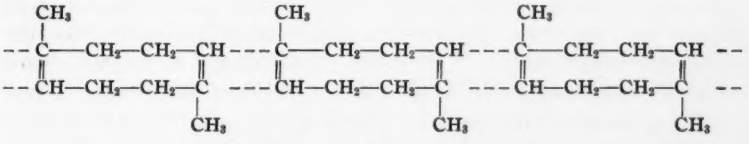
(1)



or 1,5 dimethyl cyclo octadiene.

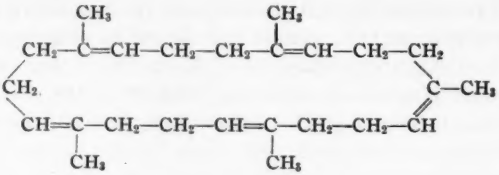
Harries first assumed that the rubber molecule consisted of a number of such rings held together by the partial valences at the double bonds which would result in a large molecule with the structure shown in (2).

(2)



Later[15] he changed his ideas and considered that the rubber molecule was a closed ring of twenty carbon atoms as represented by (3).

(3)



This formulation was based on the fact that the rubber ozonide showed a molecular weight in benzol corresponding to $C_{25}H_{40}O_{15}$. As mentioned before, the ozonide gives a molecular weight in acetic acid corresponding to $C_{10}H_{16}O_6$ which Harries attributed to a depolymerizing action of the acetic acid. It has been shown recently by Staudinger and Bruson[16] that the ozonide of dicyclo-pentadiene which may be considered as a dimolecular methylene-isoprene behaves in exactly the same way; that is, the molecular weight in acetic acid corresponds to its simplest empirical formula whereas in other liquids it is a multiple of this.

Harries reached the same conclusion, *viz.*, that the rubber molecule is a 20-carbon atom ring, from a study of the hydrohalides. Rubber can add two molecules of hydrogen chloride, for instance, for every $C_{10}H_{16}$ group. By heating this so-called dihydrochloride ($C_{10}H_{18}Cl_2$), in a vacuum at 100°, Harries[17] was able to split off HCl until it contained about 12.5% Cl. This corresponds approximately to a ring formula of $C_{20}H_{32}$ or $C_{25}H_{40}$ having one mol of HCl. These would give 11.5% and 9.4% of Cl, respectively. This behavior cannot be explained on the basis of the cyclo-octadiene formula.

Further proof that the rubber molecule contains a ring of at least 20 carbon atoms was obtained by Harries by regenerating the hydrocarbon from the hydrohalides and then ozonizing and hydrolyzing the product. When heated with pyridine, the hydrochloride splits off all the chlorine as HCl and regenerates a hydrocarbon having the same number of double bonds as the original. When this hydrocarbon is ozonized it takes up the same amount of ozone as the original rubber but the ozonide yields very different products on hydrolysis. As before stated, the original rubber yields principally laevulinic acid and laevulinic aldehyde. The so-called iso-rubber, however, yields products with long aliphatic chains, some of them containing 15 carbon atoms. These could not possibly be produced from an 8-carbon atom ring. The following compounds were obtained and identified and their formation is ascribed to a shifting of the double bonds during the regeneration of the iso-rubber from the hydrochloride.

diacetyl propane $CH_3—CO—CH_2—CH_2—CH_2—CO—CH_3$
undecatrione $CH_3—CO—CH_2·CH_2—CH_2·CO·CH_2CH_2CH_2—CO·CH_3$
pentadecatetron $CH_3·CO·CH_2·CH_2·CH_2·CO·CH_2·CH_2·CH_2·CO·CH_2CH_2CH_2CO·CH_3$

A complete review of this work is given in Harries' book.[17]

Other formulas have also been proposed such as the straight chain type suggested by Pickles[18] and Staudinger.[19] Pickles believes that the end valences of these long chains connect to form a very large ring, whereas Staudinger thinks that they remain free but are reduced in activity, due to the length of the chain, to the point where ordinary saturating forces have no effect. Staudinger also believes that these end valences are the cause of the colloidal properties and bases his reasoning on the fact that extremely minute traces of bromine will reduce the viscosity of a solution of rubber to a very marked degree.[20] Later Harries was inclined to agree with Pickles because he found that by reducing the hydrochloride with zinc dust a body having 35 or 40 carbon atoms was obtained which could be distilled unchanged.

Hydrogenation of Rubber.—Very convincing proof that the rubber molecule is very large was obtained by Staudinger and Fritsche.[21] These investigators succeeded in completely saturating the double bonds with hydrogen at high temperatures and pressures using platinum as a catalyst. The product showed the composition $(C_5H_{10})_x$. It is a clear, colorless, amorphous mass of very low tensile strength. It has a high dielectric strength and is not affected by oxidizing agents. In spite of the fact that it is saturated its formula is $(C_5H_{10})_x$, which indicates a ring structure and the molecule must be very large as it gives colloidal solutions.

On distillation *in vacuo* it yields a hydrocarbon, $C_{50}H_{100}$, along with others of even higher molecular weight but all having the same empirical formula $(C_5H_{10})_x$. This would indicate that the original molecule has at least 50 carbon atoms and that it is the primary valences which hold the isoprene groups together, at least up to a very high molecular weight.

Oxidation of Rubber.—When allowed to stand in the air, rubber will absorb oxygen, the rate depending on conditions, such as temperature, degree of vulcanization, admixtures, etc. Under certain conditions it becomes hard and brittle and the product of oxidation is soluble in acetone. Some of the oxidation products were isolated from a benzol solution of rubber through which air had been passed for some time. These products had the compositions corresponding to the formulas $C_{10}H_{16}O$ and $C_{10}H_{16}O_3$. Spiller[22] obtained a resinous oxide of the composition $C_{30}H_{48}O_{10}$ from a piece of unvulcanized rubber which had become brittle after six years' exposure to the air. This substance has since been called "Spiller's Resin." The addition of oxygen probably takes place at the double bonds with the formation of a peroxide. Depending on the temperature, water and CO_2 then split off. Laevulinic aldehyde has been identified among the oxidation products. Raw rubber does not oxidize as easily as the purified product.

Oxidizing agents such as $KMnO_4$, and H_2O_2 yield mixtures of compounds containing oxygen. Chromyl chloride which is a powerful oxidizing agent yields a definite compound $C_{10}H_{16}\cdot 2(CrO_2Cl_2)$ when added to a solution of rubber in CS_2.[23]

Boiling rubber in dilute nitric acid yields a mixture of acids of high molecular weight as well as oxalic and hydrocyanic acids.

The action of oxygen on rubber can be greatly retarded by many substances, "anti-oxidants" such as resorcinol, hydroquinone, various naphthols, and naphthylamines.

The Action of Oxides of Nitrogen.—The oxides of nitrogen react with rubber to form "nitrosites." By the action of N_2O_3 Harries obtained a difficultly soluble nitrosite "a," $(C_{10}H_{16}N_2O_3)_x$, which upon continued passage of the gas goes over into $(C_{10}H_{15}N_3O_9)_2$, which is soluble in ethyl-acetate. By using moist N_2O_3 a product of the same composition, called nitrosite "c," was obtained which was soluble in alkalies and reduced Fehling's solution.

By treating rubber with N_2O_4 Weber obtained a nitrosate, $C_{10}H_{16}N_2O_4$. Harries later showed that this is formed first but that prolonged treatment yields the same compound as N_2O_3, *viz.*, nitrosite "c." Both Harries[24] and Alexander[25] believed that identical products were obtained by the action of N_2O_3 and N_2O_4.

Depolymerization.—When a solution of rubber in toluol or xylol is boiled for 50 to 60 hours, a depolymerization or rearrangement takes place and the rubber can no longer be precipitated by alcohol. The hydrochlorides obtained from such rubber show varying properties according to the time of boiling and the solvent. Harries was able to depolymerize rubber to a mixture of cymene derivatives by boiling in xylol. The molecular weight of these depolymerization products has not been determined.

Substituted Rubbers.—By substituting the chlorine of the hydrochlorides of rubber by other groups, homologs of rubber may be obtained. Staudinger and Widmer[26] were able to produce methyl and ethyl hydro-rubbers by treating the hydrochloride with zinc dimethyl and zinc diethyl. Weber substituted the bromine of the tetrabromide with phenol and obtained what he considered to be an ether. Fisher[27] later showed that the compound was phenolic in character as it was soluble in alkali and could be methylated with dimethyl sulfate.

Attempts have been made to carry out Friedel-Crafts and Grignard reactions with the hydrohalides of rubber but as yet these products have not been characterized.

Sulfur and Sulfur Chloride.—By far the most important reactions of rubber are those concerned with the vulcanization. This process may be

carried out by heating rubber and sulfur together at temperatures of about 140°C., by dipping thin rubber articles in solutions of sulfur chloride (S_2Cl_2) or exposing them to the vapors, or by forming active (probably atomic) sulfur in the rubber by the interaction of sulfur dioxide and hydrogen sulfide (Peachy Process).

Of these methods the first is the most important. It is not definitely known exactly what takes place when rubber and sulfur react, on account of the fact that it has been impossible to isolate any compounds from the mixture. When we consider that even the nature of the rubber hydrocarbon itself is not known and that this is only one of many substances present it is not surprising that so little definite knowledge is available on the products of this very important reaction. It can be safely stated, however, in spite of the theories to the contrary, that there is a chemical reaction taking place during vulcanization, with the formation of new chemical substances. It has been stated above that there are at least two rubber hydrocarbons in the latex particle and that the molecular weight of both of them is very high. This means that for every C_5H_8 group there is one double bond. During vulcanization there is no hydrogen sulfide generated and hence the sulfur must saturate these double bonds. As the amount of combined sulfur increases there must of necessity be a series or two series of compounds formed as the double bonds are successively saturated. When all the double bonds have been saturated the theory demands a product containing 32% of sulfur and that no greater amount of sulfur can be added to the rubber without some hydrogen sulfide being formed. It has been demonstrated many times that this is true and that the end product of the addition reaction is $(C_{10}H_{16}S_2)_x$. Of the one or more series of intermediate products or the individual members of these series nothing is known as it has been impossible to isolate any of them. Weber[28] attempted to show that the physical properties of the vulcanizate were dependent on these series but he and everyone else has failed to show any definite relationship between combined sulfur and physical properties. The answer to this question is still in the future but there is no doubt that it will be solved by the combined efforts of the organic chemist, colloid chemist, and physicist.

The behavior of rubber towards sulfur chloride is in about the same category except that the end product of the reaction has not been established with certainty as yet. The final product seems to vary with conditions and as sulfur chloride also reacts with the resins, proteins, etc., present in the rubber, the same uncertainty is present here as in the case of sulfur.

Progress is being made rapidly along all lines of rubber chemistry and before many years have passed we shall probably be in a position to state fairly definitely what takes place during these important reactions with sulfur and sulfur chloride.

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OPPORTUNITIES FOR CHEMISTS

The Government Printing Office has just issued a little booklet, compiled by the United States Civil Service Commission, under the title, "Opportunities for Chemists in the United States Civil Service" (Form 2528). Grades of chemists, requirements for each grade, examinations, duties, and advantages of employment are fully discussed. Tables showing the distribution of chemists in the Government service and salaries paid are also included.

"One of the only two articles that remain in my creed of life is that the future of our civilization depends on the widening spread and the deepening hold of the scientific habit of mind; and that the problem of problems in our education is, therefore, how to discover and how to mature and make effective this scientific habit. . . . . It represents the only method of thinking that has proved truthful in any subject. That is what we mean when we call it scientific."—PROFESSOR JOHN DEWEY

SOME RELATIONS OF EARLY CHEMISTRY IN AMERICA TO MEDICINE*

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The history of early chemistry in America, when traced in all its relations, is found to be but an offshoot of those larger movements in European chemistry from which the American science derived its origin. Alchemy, iatrochemistry, and phlogiston, which had such an influence upon European thought, each had their followers in America and the conflicts of these various systems have left their mark upon the history of chemistry in the New World. The fact that the main battleground of these systems was in Europe has caused historians of science to pay but little attention to what occurred in the Western Hemisphere.

Boyle's Influence on American Chemistry
Boyle's Contributions to Medicine
Governor Winthrop as a Physician
Digby—The Pliny of His Age
Starkey—Chemical Practitioner
Mercury and Antimony
Other Items in the Early Pharmacopoeia
Lavoisier's Influence on Medicine
Early Quackeries
A Clever Satire
Physicians Leaders in Chemistry
Beaumont's Classic Work on Nutrition
From Alchemy to Modern Research

Boyle's Influence on American Chemistry

The periods of alchemy and iatrochemistry overlap in America, just as they do in Europe. It was Paracelsus who, in the first half of the sixteenth century, began the reaction against alchemy by announcing that the object of chemistry was not to make gold but to prepare medicines. But this new idea was slow in developing. The publication of works upon alchemy went on at an increasing rate and did not begin to slacken until about 1620, some 80 years after the death of Paracelsus. Iatrochemistry then began to gain the ascendency, but it held its ground only for half a century when Boyle made his famous declaration that the true aim of chemistry was neither the improvement of metals, as held by the alchemists, nor the preparation of medicines, as announced by the iatrochemists, but the experimental study of the composition of substances. Boyle, as Ernst von Meyer remarks, was the man "whom chemistry has to thank for teaching her the real aims she should pursue," yet this genius was so far from despising the works of alchemy and iatrochemistry, that he died a firm believer in transmutation and devoted several hundred pages of his published works to the discussion of chemical remedies.

Boyle's Contributions to Medicine

Although Boyle did not hold a medical degree he devised many preparations of silver, copper, mercury, and antimony for the treatment of diseases

* Paper read before the Historical Section of the American Chemical Society at the Pittsburgh Meeting, September 7, 1922.

and by the prominence of his name exerted a considerable influence not only upon the medical practice of England but upon that of the American colonies. Among the most intimate of Boyle's friends in the New World was John Winthrop, Jr., the first Governor of Connecticut. They were fellow members of the Royal Society and many letters passed between them. Winthrop's interests in alchemy and in the practical applications of chemistry to industry have been referred to at previous meetings of this section yet these interests were only secondary to his work as a chemical practitioner. Although he might have said with Boyle that physics was not his profession, it is doubtful if there was any doctor of medicine in the American Colonies during the 17th century who could equal Winthrop in the extent of his medical practice, in the number of his acquaintances among the leading physicians and chemists of Europe, or in the completeness of his laboratory and library. The works of Paracelsus, Libavius, Glauber, Croll, and other iatrochemists, which Winthrop owned, are still preserved and his marginal notes upon the pages of these show how much he made use of them.

It is interesting to compare the remedies in Boyle's "Medicinal Experiments" with the ones employed by Winthrop in New England. Boyle sided generally with the Paracelsians as against the Galenists who, clinging to the old theory of the four humors, combated disease by selecting remedies that supplied the supposed deficiency of the body in the qualities of hot, cold, wet, or dry. He was not, however, an extremist and included in his *Materia Medica* not only numerous vegetable remedies of the Galenists but also many of their disgusting superstitions for the final elimination of which from our pharmacopoeias the School of Paracelsus may claim the chief credit. And so we find in Boyle, side by side with such chemical remedies as dulcified mercury and crocus metallorum, such vegetable prescriptions as the juice of turnips and radishes and such abominations as powdered bones from cemeteries and the excrement of animals.

Governor Winthrop as a Physician

Winthrop, like Boyle, was an eclectic in the choice of his remedies but it must be said to his credit that except for an occasional electuary of sow-bugs there was nothing particularly revolting in his prescriptions. The principal chemical remedies which he used were saltpeter, antimony, tartar, copperas, white vitriol, sulfur and iron, with occasionally a little calomel. In addition to these, Winthrop also prescribed red coral, powdered ivory, rosin, saffron, sassafras, aloes, balsam, rhubarb, and various simples of the Galenists, such as wormwood and anise.

The chemical remedies employed by Winthrop are usually indicated in his letters and records by the old alchemistic symbols, the details of his cases sometimes being written in Latin. A mystery exists about

some of his remedies, a secret alphabet being used to conceal particularly private information. This secrecy was especially marked as to the medicine called "Rubila" which was invented by Winthrop and employed by him for treating ague, small-pox, worms, coughs, and other complaints. The fame of this remedy spread over all New England and even to Great Britain. Its composition has never been determined with certainty. According to Dr. Oliver Wendell Holmes, it probably consisted of diaphoretic antimony, nitre, a little salt of tin, and some substance for "rubifying" or giving the mixture a red color.[1]

Nitre and antimony were the chief chemical remedies of Winthrop, concerning whose use of these, Dr. Holmes remarked that nitre was "a pretty safe medicine in moderate use and one not likely to keep the good Governor awake at night, thinking whether it might not kill if it did not cure" while diaphoretic antimony, although "a mild form of that very active metal, left his patients very commonly with a pretty strong conviction that they had been taking something that did not exactly agree with them."

Winthrop's patients comprised all classes from sick Indians up to Colony Governors. The appeals to him for medical aid were frequent and the preparation of remedies often kept him from other obligations. "I am now intent upon extracting nitre," he writes his son, "and cannot think of any journey till that be accomplished." According to Cotton Mather, Winthrop gave away his remedies "upon all occasions insomuch that wherever he came, still the diseased flocked about him as if the healing Angel of Bethesda had appeared in the place." Another picture of the philanthropic old Governor, working in his laboratory, has been left by a contemporary New England poet.

> His fruits of toyl hermetically done
> Stream to the poor as light doth from the sun.
> The lavish garb of silks, Rich Plush and rings,
> Physicians' Livery, at his feet he flings.
> One hand the bellows holds, by t'other Coals
> Disposes he to hatch the health of Souls.

[1] The author several years ago found in the John Winthrop, Jr., collection of the Massachusetts Historical Society at Boston a letter which was stained with a red powder and suspecting this might be due to Rubila he requested Mr. Julius Tuttle, the librarian, to send a clipping of the paper to Prof. E. M. Chamot of Cornell University who very kindly offered to subject the material to a microchemical analysis. The result of the examination is thus given by Prof. Chamot.

"If a conclusion is justified from the study of the clippings of a single stained letter, it is that Dr. Oliver Wendell Holmes was substantially correct in his suggested composition of 'Rubila.' My tests show that nitrate of soda (the nitre of Winthrop?) and antimony sulfide still cling to the paper or are incorporated in the paper fiber. There may also possibly be some tin salt present as Holmes has suggested, but my tests are so inconclusive that this compound must be reported as absent so far as these

How much this description of Winthrop resembles that which Paracelsus gave of the chemical practitioners of the previous century!

> They do not go idly about in gorgeous suits of satin, silk and plush, with gold rings on their fingers, silver daggers at their sides and white gloves on their hands, but they tend patiently to their work at the fire day and night. They do not go promenading around, but seek their diversion in the laboratory, wearing rough leather garments with aprons on which to wipe their hands and thrusting their fingers amongst the coals into dirt and grime.

Digby—The Pliny of His Age

Another fellow member of the Royal Society with whom Winthrop corresponded upon medical subjects was Sir Kenelm Digby. It is doubtful, however, if this visionary alchemist imparted much to his New England friend in the way of practical remedies. In a letter to Winthrop in 1656, Digby writes as follows: "For all sortes of agewes I have of late tryed the following magneticall experiment with infallible successe. Pare the patient's nayles when the fit is coming on and putt the paringes into a little bag of fine linen, or sarsenet, and tye that about a live eele's necke, in a tubbe of water. The eele will dye, and the patient will recover. And if a dog or hog eate that eele they will also dye." Digby was called the Pliny of his age but there is nothing in Pliny which can compare with this "magneticall remedy for the agewe."

Digby is best known as the inventor of the sympathetic powder concerning which he gave Winthrop a brief account in the conclusion of the letter above-mentioned.

> I was the first that brought the sympathetike powder into England and France 35 yeares agone. King James made tryall of it from my instruction. And the case of Mr. James Howell (whom I believe you know) was famous. All vitriol is alike, onely the best worketh most efficaciously. And the other additions to it, are but to make the thing the more mysterious. Such medicines (in any kind) as you shall thinke fitt to imparte to me, I shall receive as singular favours: And in what so ever you shall judge me capable to serve you, command me freely, for I am with all my heart
>
> Your most affectionate and humble servant,
>
> Kenelm Digby

Digby's sympathetic powder, as he intimates, was prepared from vitriol. It healed not by contact but by being applied to the knife or object which produced the wound, or to the bandage taken from it. This remedy was used in the English colonies and with other medico-chemical topics was a subject of debate in our American colleges. At Harvard the question "Is there a sympathetic powder?" was decided in the affirma-

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fragments are concerned, but I feel quite sure that in this particular prescription, Dr. Holmes was wrong—it did not contain diaphoretic antimony but sulphuretted antimony, which I believe was even more commonly employed by practitioners of the 17th and early 18th centuries."

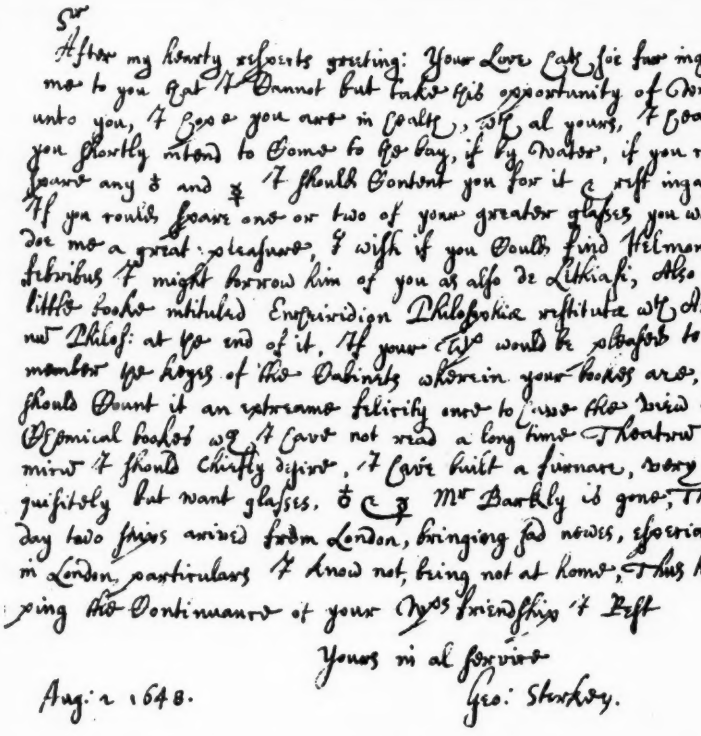
tive in 1703, 1708, and 1710. The question "Is the cure of wounds by the sympathetic powder lawful?" was decided in the affirmative in 1693 and 1708. The question "Are there diseases which are not cured by Galen's remedies but only by chemical ones?" was decided in the affirmative in 1701. These decisions are probably typical of the most intelligent opinion in America two hundred years ago.

Starkey—Chemical Practitioner

Among the protégés of Winthrop in the Massachusetts Bay Colony was a young Harvard College graduate of the class of 1646 named George Starkey who was destined to win great renown as a chemical practitioner. In an interesting letter written shortly after his graduation, Starkey informs Winthrop that he had built a furnace in Boston and wished to borrow from him a little mercury, antimony, and a few glass vessels. He also asks Winthrop to lend him his Helmont and other chemical books. A few years later Starkey went to England where he published numerous books defending the art of Paracelsus and Helmont against the Galenists. He also invented numerous remedies of which his oil of sulfur was the best known. Starkey died of the great plague which ravaged London in 1665.

Mercury and Antimony in Early American Medicine

Mercury and antimony, the two metals which Starkey solicited from Winthrop, were the principal bases of the chemical remedies used in America for the next two centuries. This does not appear so remarkable when it is remembered how important a part the mercurial and antimonial remedies played in the works of Basil Valentine, Paracelsus, Helmont, Glauber, Boyle, Boerhaave, and Cullen. According to Basil Valentine, mercury and antimony derived their virtues from the same planet. Both metals were poisons and, according to the rule of like attracting like, acted medicinally by drawing to themselves the poisonous principles which produced disease. According to a later theory, somewhat similar, disease was produced by a morbific agent which must either be purged away by mercury, or sweated away by antimony. Glauber, sometimes called the last of the iatrochemists, wrote pages upon the virtues of antimony and laid down the rule that when well prepared it is never taken in vain, while Boyle stated that antimony may afford a variety of medicines sufficient to furnish a shop. According to both Glauber and Boyle, antimony could cure by simple contact. The so-called "perpetual pills" of the chemical practitioners were simply pellets of antimony which after passing through the body could be used over and over again with continual benefit. In the same way the antimonial cup, used by our colonial ancestors and of which Glauber and Boyle describe the merits, imparted its virtue to the wine or water which the patient drank from it.



Sir: After my hearty respects, greeting. Your love hath soe far ingaged me to you, that I cannot but take this opportunity of writing unto you. I hope you are in health, with al yours. I heare you shortly intend to come to the bay; if by water, if you could spare any ♂ and ☿, I should content you for it & rest ingaged. If you could spare one or two of your greater glasses, you would doe me a great pleasure. I wish, if you could find Helmont de Febribus, I might borrow him of you, as also de Lithiasi, also the little booke intituled Encheiridion Philosophiae restitutae, with Arcanum Philos. at the end of it. If your Worship would be pleased to remember the keyes of the cabinets wherein your bookes are, I should count it an extreme felicity once to have the view of chemical bookes, which I have not read a long time. Theatrum Chemicum I should chiefly desire. I have built a furnace, very exquisitely, but want glasses, ♂ & ☿. Mr. Barkly is gone. This day two ships arived from London, bringing sad newes, especially in London, particulars I know not, being not at home. Thus hoping the continuance of your Worship's friendship, I rest

Yours in al service

Geo. Starkey.

Aug. 2, 1648.

Letter of George Starkey (Harvard, 1646) to John Winthrop. This, so far as known, is the earliest chemical letter written by the graduate of an American college.

♂ Alchemistic sign for antimony.
☿ Alchemistic sign for mercury.

The drastic use of mercury and antimony by our Colonial forefathers is well illustrated in the famous method of mercurial inoculation for small-pox, invented by Dr. John Muirson of Brookhaven, Long Island, in 1731. This method consisted in preparing the body for the inoculation by the administration of heavy doses of calomel which were followed by equally heavy doses of powdered antimony, cream of tartar, and brimstone. After several weeks of this treatment the medicines were stopped and the patient inoculated with small-pox, which was allowed to run its course. The purging and sweating away of the supposed morbific matter, on which the contagion fed, were thought to weaken the virulence of the disease so that the attack was a mild one. This method of inoculation was used extensively for some fifty years during epidemics of small-pox in New York, Philadelphia, Boston, and Baltimore; it was even introduced into London.

The reliance upon antimonial remedies for almost every form of disease continued well into the nineteenth century. Dr. William Beaumont, to whom we shall refer again later, used them constantly during the War of 1812, while he was a physician in the United States army. For fevers, dysentery, pleurisy, pneumonia, and other camp diseases he wrote, "Depletion by blood-letting and antimonial sudorifics and diaphoretics, and an entire disuse of all tonic medicines, is the proper plan of cure." The extensive application of antimonials to every kind of disease for over two centuries shows what an influence emanated from that remarkable book, attributed to the mythical Basil Valentine, "The Triumphal Chariot of Antimony."

Other Items in the Early Pharmacopoeia

Although the use of antimony furnished for centuries the great criterion which distinguished the followers of Paracelsus from those of Galen, the early chemical practitioners in America did not limit themselves to the use of this and other mineral remedies. Various organic substances such as rosin, balsam, turpentine, and other essential oils found an important place in their pharmacopoeia. Tar was also greatly used, the method of preparing which in New England was the subject of a paper read by John Winthrop before the Royal Society in 1662—the first contribution, by the way, of any American before a scientific association. Tar, when stirred into water, is partly dissolved and this solution, taken internally, was supposed to have remarkable curative properties.

Tar water was recommended as a remedy by no less an authority than the celebrated philosopher, Bishop Berkley.[2] Its preparation and composition were the subject of a special paper, read before the Royal Society

[2] Bishop Berkley resided in Rhode Island from 1728 to 1731 during which period he no doubt became familiar with American tar and its properties.

and published in 1745, by Dr. Stephen Hale, best known for his work on "Vegetable Statics." Dr. Hale compares American tar with that of other countries and suggests that the medicinal virtue of tar water may be due "to a fixed alkaline salt, intimately united with the oil of the tar and making thereby a penetrating, detersive soap."

Lavoisier's Influence on Medicine

With the foundation of modern chemistry by Lavoisier, great changes were introduced into the theory and practice of medicine, as the old ideas concerning animal heat, respiration, and other functions of the body had to be revised. In this interesting period of reconstruction in American chemistry, when the transmutation of base metals into gold was still being attempted and when phlogiston and antiphlogiston were fighting for supremacy, there is no more interesting figure than Dr. Aeneas Munson of Yale University. He was known at one time as an experimental alchemist and the diary of President Stiles of Yale contains several conversations which he held with Dr. Munson upon the hermetic art. Always a zealous student of chemistry, the doctor loved to depict the great discoveries which were to be made in this science. He had a practical knowledge of the applications of chemistry and manufactured many of his own medicines and extracts. Although originally a believer in phlogiston he was among the first in America to adopt the theories of Lavoisier and to employ the remedies which the new discoveries in chemistry suggested. Many stories have come down of Dr. Munson's racy wit and fondness for practical jokes. On one occasion a student who felt ill secured a certificate of indisposition from Dr. Munson which he presented to President Dwight with a request to be excused from college exercises. The worthy head of Yale asked to see the student's tongue and finding this member clean refused to grant the excuse. Dr. Munson on being informed of this gave the student some coloring substance telling him to chew it and report again to the president. The student did as directed and his tongue this time being found discolored the excuse was promptly granted.

Early Quackeries

In an interesting oration delivered before the Chemical Society of Philadelphia in 1801 by Dr. Felix Pascalis, reference is made to the fallacious remedies which were foisted upon an overcredulous public in the name of the new discoveries in chemistry, very much as similar follies are perpetrated today in the name of vitamins and radio-activity. One such delusion referred to by Dr. Pascalis was the gas cure in which diseases were treated by applying oxygen and other newly discovered gases. Another similar craze of this period, known as tractoration, swept over the United States and England in the wake of the discoveries of Galvani.

If Galvani could produce electrical irritations and convulsions in a muscle by applying two points of different metals, then, according to the reasoning of Elisha Perkins of Connecticut, an inflamed or diseased organ of the body must contain an excess of electric fluid, the simple withdrawal of which, through brass and iron points, will allay the morbid affection. The implements for withdrawing this surplus of electric fluid were patented by Perkins in 1796 under the name of *metallic tractors* and wonderful reports were circulated of the cures which they accomplished. A Perkinean Institution was established in London under the presidency of Lord Rivers and 5000 cases of cures were published with certificates of professors, physicians, and surgeons.

A Clever Satire

The craze of Perkinism was made the subject of an amusing poem called "Terrible Tractoration by Christopher Caustic, M. D.," written by Thomas Green Fessenden of New Hampshire, during a visit to London in 1803. A few extracts are quoted from this long-forgotten satire which discussed not only tractoration but oxygen, nitrous oxide, fulminate of mercury, and other chemical fads of the period.

Christopher Caustic, a drug doctor of the old school, looks with suspicion upon the application of the new discoveries of his time to medicine and hygiene, although he says when it comes to startling "chymical" experiments he is equal to any one. He writes in a footnote:

> Just thirty-two years since, while I was prosecuting some of my chymical researches, my eldest son Tom overturned a bench on which were placed seven carboys full of acids, alkalies, etc., and broke them into inch pieces. The whole neighborhood was alarmed and many most terribly causticized in endeavoring to extinguish the conflagration. In the consternation some one cried out "Dr. Crichton (for such was my former name, being the lineal descendent from the celebrated 'admirable Crichton') is fairly a Dr. Caustic." Thus began my honorary name of which, as it is scientific, I am not a little proud especially as it was acquired by virtue of an explosion. For further particulars you will please to inquire at the Herald's College, which has done me the justice to register the occurrence. Instead of lions, bulls, boars, camels, elephants and such insignificant animalculae, my shield is decorated with insignia more appropriate to my great pretensions. On the left are seen broken carboys *couchant*, implying that the secrets of science are prostrate before me. On the right are fumes *rampant*, indicative of my discoveries which soar above those of all other pretendors.

Thornton's gas cure and other innovations for treating disease are to Dr. Caustic snares and delusions, but nothing excites his wrath so much as metallic tractors and the new Perkinean Institute of London, which he fears will soon put the drug doctors out of business. After thinking of all possible punishments to visit upon the Perkineans, Dr. Caustic can conceive of nothing more horrible than forcing them to take heavy doses of his own drugs. His poem concludes with fierce invectives as he leads his followers against the enemy.

Come on! Begin the grand attack
With aloes, squills and ipecac,
Sound Discord's jarring tocsin louder
Than Howard's fulminating powder.
Cram all the ninny-hammers' gullets
With pills as big as pistol bullets;
And mingle mercury enough
To season well your doctor's stuff.
Dash at them—acid, huge carboys
Filled to the brim like Margate hoys.
With antimonials make them sweat away;
Cram each snout full of asafoetida,
And though the drug seem somewhat baleful
Give each a dose of half a pailful.
Let not one Perkinite be found
Encumbering our British ground.

So much for Dr. Caustic over whom the chemists of America and England a century ago enjoyed many a laugh. Fessenden's farcical poem, although satirizing the forgotten follies of an age when modern chemistry was young, has still much entertainment for those who enjoy a little nonsense with their science.

After a brief ten years of prosperity the metallic tractors went the way of rubila, the sympathetic powder, the antimonial cup, mercurial inoculation, tar water, and the long list of other chemical remedies employed by our Colonial ancestors.

The Medical Profession Leaders in Chemistry

It would be wrong, however, and far from the purpose of the present sketch, to create the impression that the only fruit of the relations of early chemistry and medicine in America was a lot of obsolete remedies. For two centuries after the settlement at Jamestown, physicians were almost the only devotees to chemistry in America. It was, therefore, natural that the first professors of chemistry in American colleges and the first authors of American text-books upon chemistry should have been physicians. Doctors Rush, Woodhouse, Hare, Mitchill, Maclean, McNevin, Ewell, Cooper, and many others might be named in this connection. It is significant also that the leaders in those first associations of chemists in America, the Chemical Society of Philadelphia, and the Columbian Chemical Society, were mostly physicians.

The medical profession maintained this precedence in chemistry not only in educational and public matters but also in the field of chemical industry. Dr. Gerard Troost, for example, was a professor of chemistry and also one of the first in America to begin the manufacture of alum. Another physician, Dr. Samuel L. Dana, was also a manufacturer of chemicals. As the inventor of the American system of bleaching and of im-

provements in calico printing, Dana was America's first textile chemist and as the author of the celebrated "Muck Manual for Farmers," he was also America's first agricultural chemist. Another medical graduate, Dr. John Torrey, best known for his botanical studies, was not only a professor of chemistry at West Point and Princeton but during the last twenty years of his life directed the United States Assay Office in New York.

It could hardly be expected that much attention would be given to chemical research in the rough environment of pioneer American life. Yet many very creditable pieces of research were undertaken by physicians in the early days of American chemistry, such, for example, as that of Dr. Normandie in 1768 upon chalybeate waters and that of Dr. M'Causlin in 1789 upon the earthy substance in the spray of Niagara Falls. These and other early chemical researches by American physicians were published in the *Transactions of the American Philosophical Society* and as Prof. Smith has pointed out in the first chapter of his "Chemistry in America" they "testify to a spirit of inquiry on the part of our early devotees to science." There is not space to review the long list of chemical researches conducted by early American medical graduates but reference will be made to two of them as they relate to a subject in which a long line of American chemists have won distinction—*viz.*, the science of nutrition.

The first person in America to begin the experimental study of nutrition was Dr. John Lining, a physician of Charleston, South Carolina, and a corresponding member of the Royal Society. Throughout the entire year of 1740, Dr. Lining conducted an experiment upon himself by which it was shown that he took in nourishment and drink 42,443 ounces, and that in the same time he discharged by perspiration 19,721 ounces, by urine 21,276 ounces, and by stool 1428 ounces. His body lost in weight from April to October and gained in weight from October to April. This early investigation is significant, for experimental research was at that time almost unknown in America.

Beaumont's Classic Work on Nutrition

The name which stands out most prominently among early American investigators in physiological chemistry is that of Dr. William Beaumont, whose pioneer work upon gastric digestion has become a classic. As the present year (1922) is the centennial anniversary of the circumstance which led to Beaumont's researches, a brief reference will be made to his life and work.

William Beaumont was born in 1785 in Lebanon, Connecticut. After attending school in his native town he taught for a few years and then began the study of medicine under Dr. Benjamin Chandler of St. Albans, Vermont. In 1812 he was granted a commission as physician in the

United States Army where he was actively occupied during the War of 1812. On the resumption of peace he began the practice of medicine in Plattsburgh, N. Y., but in 1820 accepted a reappointment to the army service as post surgeon at Fort Mackinac, on the Michigan frontier.

On June 6, 1822, a young French Canadian at Fort Mackinac, named St. Martin, was accidentally wounded by the discharge of a gun which carried away a part of the front wall of his stomach. Dr. Beaumont attended the injured man and succeeded in restoring him to health, although he was unable to close the wound completely. A small opening was left and it was through this aperture that Beaumont began in the spring of 1825 his first experiments upon gastric digestion. There is not time to review these experiments which extended intermittently over a period of eight years. Samples of meat and other foods, variously prepared and fastened to a silk string, were introduced through the opening into St. Martin's stomach and being withdrawn at regular intervals the progress of digestion was noted. Beaumont also removed through the aperture samples of gastric juice with which he made experiments upon digestion in glass vessels. He submitted samples of gastric juice for chemical analysis to Prof. Dunglison of the University of Virginia and to Prof. Silliman of Yale. Another sample was also sent in 1833 to Berzelius in Stockholm, but the quantity of juice seemed to the latter too small to warrant an extended investigation and his meager report was a great disappointment.

In 1833 Beaumont published at Plattsburgh the first edition of his "Experiments and Observations on the Gastric Juice." It is a poorly printed pasteboard octavo volume of 280 pages, a crude piece of typography according to present standards, yet few works are more prized by the collector of old scientific books.

An excellent life of Beaumont was published in 1912 by Dr. J. S. Myer. In an introduction to this biography by Sir William Osler, the achievements of Beaumont are thus summarized.

> His experiments settled finally the chemical nature of the digestive process so much discussed from the days of Reaumur (1752) and Spallanzani (1783). To appreciate the importance of Beaumont's experiments we must read contemporary accounts of the nature of the stomach digestion in which the old views of concoction, putrefaction, trituration, fermentation and maceration are all considered. Among other important observations may be mentioned the confirmation of the discovery by Prout of the presence of hydrochloric acid in the gastric juice; the recognition that the essential elements of the gastric juice and the mucus secretion were separate; the fuller and more accurate comparative study of digestion in the stomach and outside the body; the study of the digestibility of different articles of diet which remains today one of the most important contributions ever made to practical dietetics; the relation between the amount of food taken and the quantity of gastric juice secreted; and many other points, the true significance of which have not been recognized until the recent researches of Professor Pavlow.

From Alchemy to Modern Research

The two centuries of this sketch, covering the time from John Winthrop to William Beaumont, witnessed the transition from mediaeval alchemy to the modern era of scientific research. Through the many fluctuations of opinion that characterized this period, there was one idea which in various forms persisted unchanged, *viz.*, the belief that chemistry, at one time or another, would provide medicine with a remedy for every disease. Paracelsus foretold that there would come a Golden Age, when that Messiah of the Alchemists, Elias the Artist, would appear for the relief of suffering humanity. Glauber over a century later prays that Elias the Artist may soon discover the predicted Golden Age when true medicine and the most noble art of chemistry will begin to flourish. John Winthrop, in a letter from a European friend, was notified that this Elias had in fact already been born.

In the eighteenth century this hope in the coming of a supernatural chemist was supplanted by an extravagant belief that the new discoveries of oxygen, galvanism, etc., would in some way provide the physician with infallible remedies. Modern chemistry, although it has discovered medicines which would have seemed miraculous to the old practitioners has taught conservatism and put an end to the belief in its power to provide a cure for every kind of disease. The faith in the great benefit of the association of chemistry with medicine has, however, remained. This was well expressed by young Beaumont at the beginning of his medical career when he wrote that he hoped to win proficiency in an art "which, under the modern improvements of Chemistry and Physiology, bids fair to rise with healing on her wings." It is safe to predict that this much of the old belief will always be confirmed.

A NEW METRIC MAGAZINE

The Metric Association, 156 Fifth Avenue, New York, has begun the publication of a quarterly magazine under the name *Measurement.* The purpose of the new magazine is to meet the need of and demand for a national medium for the exchange of information on weights and measures problems, and this need has been emphasized by the steady growth of the metric movement, the success of the educational work of the Association, and the trend toward the practical use of metric weights and measures in everyday life.

The first issue carries interesting contributions from Henry D. Hubbard, secretary of the United States Bureau of Standards; Herbert T. Wade, joint author with Hallock of "The Evolution of Weights and Measures," committee reports and reprints of noteworthy editorials from other publications.

It is expected that the newcomer to the field of publications will not only fulfil its present promise of giving wider publicity to the various activities of the Association, but will bring measurably nearer the day of simplicity, sanity, and uniformity in our weighing and measuring.

DIABETES AND ITS TREATMENT

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The great interest in diabetes among physicians and the laity is due to the frequency of occurrence of the disease and the recent discovery of insulin. Approximately one person in each hundred of the population has diabetes, thus totalling one million cases for the United States. The discovery of a specific treatment for such a common and serious disease by Drs. Banting, Best, Collip, and MacLeod at Toronto, Canada, and the spectacular results obtained from the use of insulin by physicians throughout the world, has occasioned widespread enthusiasm and thanksgiving among the medical profession and their diabetic patients.

Diabetes is not a disease of the kidneys, but of the pancreas. It comes on insidiously and without pain. Eventually it causes loss in weight, fatigability, mental depression, and finally, if improperly treated, death.

The symptoms of diabetes are thirst, excessive appetite, and increased urination with sugar in the urine. The common complications are itching of the skin, neuritis, change in acuity of vision, gangrene, and coma.

Diabetes is a disease of disturbed metabolism. It occurs most often in fat people. There is some tendency to hereditary transmission. It is not contagious. Infections of teeth, tonsils, gall bladder, and other organs, together with dietary errors, are undoubtedly the chief causes of this disease. As a result of these factors, the pancreas becomes unable to produce sufficient active insulin to effect the complete combustion of sugar; and when metabolism of sugar fails, neither proteins nor fats can be properly utilized by the body.

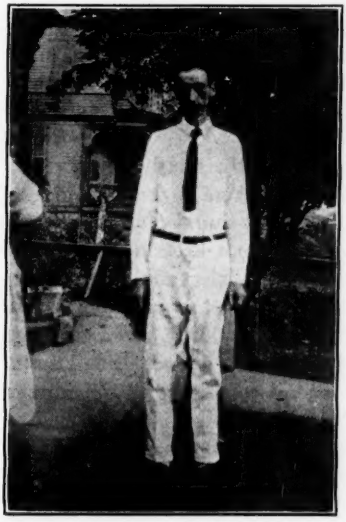
Prior to the isolation of insulin from the pancreas of cattle by the Canadian investigators, mild cases of diabetes could be successfully treated, as a rule, by regulating their diet so as to contain a limited amount of carbohydrate foods, but the severe cases declined more or less rapidly notwithstanding strict adherence to a diabetic diet, and in many cases treatment was hopeless. Before the use of insulin, diabetes in children was usually fatal within one or two years of its onset. Now, by the aid of insulin and dietary measures, practically all cases of uncomplicated diabetes can be restored to complete health and children can be treated as successfully as adults.

Insulin is not a cure in the usual sense of this term, but its use restores health. When this has been accomplished, many patients can then discontinue the insulin but must continue to live on a properly constituted diet comparatively low in sugar-producing foods. Advanced or severe cases of diabetes can remain in health only by the continued use of insulin. The insulin is given subcutaneously, usually once a day. Its use by mouth is not effective.

Dietary regulation is just as essential when using insulin as when treat-

ing diabetes by diet alone. With insulin, however, a perfectly normal and natural diet may be eaten. The amount of measured carbohydrate in the diet is limited only by the amount of insulin taken. It has been shown by Sansum and corroborated by the writer that the greater the amount of carbohydrate in an equicaloric diet, the greater is the efficacy of the insulin. Thus a rather severe diabetic who required fifty units of insulin (Iletin, Lilly) to completely metabolize a diet of 87 grams carbohydrate, 63 grams protein, and 190 grams fat, required only 72 units for a diet of 242 grams carbohydrate, 63 grams protein, and 121 grams fat. Each of these diets furnished about 2310 calories, yet the addition of 155 grams carbohydrate to the former diet necessitated the use of only 22 units more of insulin.

J. C. F.—October, 1918, weight 185 pounds.



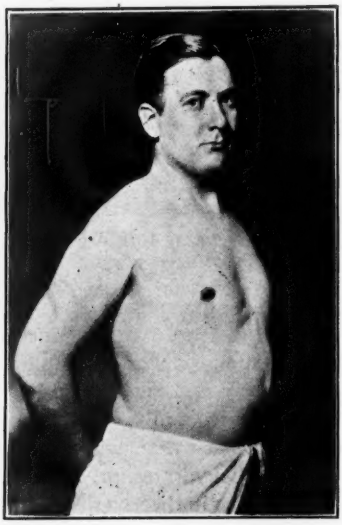
J. C. F.—October, 1922, weight 92 pounds.

The chief advantages of the high carbohydrate diet are its naturalness, thus often avoiding embarassment, the increased energy and better health it affords the patient, and, as the author believes, an increase in tolerance of the patient for carbohydrates, or, in other words, a lessening in the severity of the disease. The added cost of the increased dose of insulin is entirely offset by the lessened cost of the high carbohydrate over the high fat diet.

It is not the purpose of this paper to give in detail a method of treating diabetes. Many such articles have appeared in medical journals during the past three years. Suffice it to say that the most important feature in the treatment is the education of the patient concerning the nature of the disease, the computation and use of weighed diets, and the use of insulin. The

ideal treatment will provide the patient with sufficient food to maintain mental and muscular activity with a desirable body weight, without causing sugar in the urine or an excess of sugar in the blood. If insulin is required to bring about this condition, then insulin should be administered.

With regard to foods, it is not so important which foods shall be eaten, as it is how much of them is eaten. A diabetic may choose between 20 grams of bread, 100 grams of orange, and 300 grams of a green vegetable, as each of these contain approximately the same amount of carbohydrate and an equal number of calories. Naturally, 300 grams of vegetables will better satisfy the appetite, in addition to forming bulk for the intestinal tract.



J. C. F.—June, 1924, weight 170 pounds.

It is not necessary for practical purposes to compute in advance the number of calories required in the daily menu of a diabetic according to his age, sex, or weight. Each patient should receive the least number of calories which will hold him at a desirable weight and in diabetics this weight should be slightly less than that which is normal for the individual being treated. If a diet containing 2000 calories fails to do this, more food should be given, and, on the other hand, less should be given if the patient continues to gain beyond this predetermined weight.

Concerning the relative proportions of carbohydrates, proteins, and fats much might be said. However, suffice it to say that proteins should be relatively low, not exceeding as a rule one gram of protein for each kilogram of body weight (adults expending excessive muscular energy, and young children may require more). In adults not less than one gram of carbohydrate should be given for each kilogram of the normal body weight, and in patients not requiring insulin, as much more carbohydrate may be given as is consistent with a normal blood sugar. The remainder of the needed calories is to be supplied as fat. It should be understood that an entirely different regime may have to be instituted in beginning the treatment of a diabetic and that the above statements apply to the continuation of treatment after the patient has reached a metabolic equilibrium.

As for the patient who is taking insulin the same figure for protein may

be used, but in the writer's opinion, a carbohydrate intake which approaches that of a normal diet (3.5 grams per kilogram) will eventually prove most satisfactory even though it requires a few more units of insulin per day. This seems especially desirable for young diabetics and for those actively engaged in work.

It should be explained to the patient that insulin is not a drug but a normal body constituent which in his case is produced in insufficient quantity; and that this deficit must be introduced into the body from some other source. The administration by the subcutaneous route is carried out by the patient himself with but little inconvenience and with very little danger to the properly instructed patient. The chief danger from insulin arises from the administration of an overdose, producing too great a lowering of the sugar in the blood, which results in dizziness, faintness, nervousness, and sweating as the early symptoms. A lump of sugar eaten during the occurrence of such symptoms immediately restores the patient to normal. Neglect to have such an antidote available may lead to stupor, unconsciousness, and more dire results. With the present knowledge of insulin, harmful effects are very rare indeed.

Insulin, in the past three years, has saved thousands of lives; it has restored to health many other thousands of invalids and semi-invalids; it has enabled wage earners to resume their work and become economic assets rather than liabilities; and finally, it has maintained in health, children who, without insulin, would inevitably have died.

Only one striking case illustrative of many others is presented here: A young college boy in the year 1918 was eighteen years of age. Sugar was discovered in the urine and dietary treatment immediately begun. By reason of the perseverance of his mother and the persistence of the patient in adhering to the proper diabetic diet, the boy was enabled to live until the first commercial production of insulin by Eli Lilly & Company four years later. During these four years his weight decreased from 185 to 90 pounds. He was too weak to rise from his bed when the first dose of one unit of insulin was given in October, 1922. The diet was gradually increased and the insulin likewise, until in June, 1924, the previous weight and health of the patient were completely restored. This young man, after a lapse of six years, is now completing his medical education, and is a living monument to the discoverer of insulin and the value of chemical and medical research.

Experiment is the interpreter of nature. Experiments never deceive. It is our judgment which sometimes deceives itself because it expects results which experiment refuses. We must consult experiment, varying the circumstances, until we have deduced general rules, for experiment alone can furnish reliable rules.—LEONARDO DA VINCI

SYNTHETIC AMMONIA BY CATALYSIS

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Scientific interest and economic necessity have stimulated effort to make the nitrogen of the air more readily available for our agricultural and other needs. The methods provided by nature for the recombination of atmospheric nitrogen are too slow for the high speed age in which we now live. By means of suitable accelerators, however, the apparently inert nitrogen can be made to react so readily that we need no longer be exercised about the supply of fixed nitrogen. Last year, for example, approximately 30 per cent of the world's nitrogen requirements was produced with the aid of accelerators or catalysts. It is the purpose of this paper to present some features of the catalytic method of fixing nitrogen which have been of importance in its industrial application.

Since nitrogen and oxygen occur already mixed in the air we breathe, it is not surprising that the earliest attempts to fix nitrogen involved the direct combination of these two gases. It had been observed that oxides of nitrogen are formed when electric sparks are drawn through air. Although years of effort have been spent in the study of the spark or arc method, it is still a very inefficient method. At present, only about 2.5 per cent of the electrical energy expended can be accounted for in the product formed. Compared with most electro-chemical processes, the arc method is extremely wasteful and can be a factor in nitrogen fixation only in those localities where very cheap electrical energy is available.

The effort to combine nitrogen directly with hydrogen has been much more successful. Just as nitrogen can be made to combine with oxygen by subjecting the mixed gases to the action of an electric discharge, it can also be made to combine with hydrogen under similar conditions. The amount of ammonia formed is extremely small, however; so small, in fact, that one of the early experimenters, Morren (1859), was obliged to circulate the gas mixture repeatedly through the spark chamber, absorbing the ammonia formed after each passage, before any appreciable amount of the gas was obtained. But the synthesis of ammonia by means of the electric spark has never produced any promising results. Probably the most important contribution by those experimenters who hoped that electricity would solve the ammonia synthesis problem was the discovery that ammonia was not completely decomposed by heat or electricity. In other words, the combination of nitrogen and hydrogen to form ammonia is a balanced or reversible reaction whose characteristics permit the decomposition of ammonia by heat or electricity to proceed only so far. Le Chatelier was the first (1884) to point out the factors which influence such reactions. He showed that when heat is evolved by a balanced reaction, an increase in temperature tends to reverse the reaction. He also showed that when a decrease in volume accompanies the reaction, which happens to be the

case when ammonia is formed from its elements, an increase in the pressure of the reacting gases should increase the amount of ammonia produced.

It was Le Chatelier's belief that nitrogen and hydrogen ought to combine rapidly if the mixed gases were sufficiently compressed. Accordingly, he compressed a mixture of nitrogen and hydrogen to 200 atmospheres, which was the highest gas pressure with which investigators were familiar at that time (1900). The experimental apparatus was also equipped with an electric sparking device. The compressed gases did not combine until the electric spark was applied, when a terrific explosion followed which killed Le Chatelier's assistant. This result was at first thought to be indicative of the rapid rate with which compressed nitrogen and hydrogen combined at high pressures, particularly under the influence of an electric spark. Close examination of the experimental apparatus employed by Le Chatelier disclosed the fact that the cock for lubricating the compressor had been left open and that air had been permitted to mix with the nitrogen-hydrogen mixture during the compression. It is not surprising that a violent explosion followed when such a gas mixture was sparked. When Le Chatelier discovered the cause of the explosion, he became convinced that the combination of nitrogen and hydrogen was extremely slow, certainly at pressures as low as 200 atmospheres, unless a suitable catalyst were present in the gas mixture.

The first reliable account of an experiment in which ammonia was actually made synthetically was published in 1904. In this experiment, by Perman, ammonia was made by passing a mixture of nitrogen and hydrogen through a red hot glass tube containing iron. Perman checked his experiment by passing a similar gas mixture through a similar red-hot glass tube which did not contain iron. In the latter case he did not obtain any ammonia. It had taken about 100 years to demonstrate that nitrogen and hydrogen will combine in the presence of a suitable contact material; it took less than ten years to develop this possibility into an important industry.

Real progress in the development of the direct synthesis of ammonia did not begin until quantitative data concerning the reaction became available. Le Chatelier's theoretical consideration of the ammonia reaction was of interest, but it did not serve as a basis for predicting the amount of ammonia which could be formed at any given temperature and pressure. This phase of the problem was attacked independently by two German scientists, Prof. Fritz Haber and Prof. Walter Nernst, about 1900. Haber attempted to determine by experiment the maximum amount of ammonia which could be formed when nitrogen and hydrogen were in equilibrium with ammonia. Nernst, on the other hand, attempted to compute this and other chemical equilibria from heats of reaction and certain "chemical constants." His calculated values agreed very well with results which had

been obtained experimentally for a number of reactions, but did not check with the experimental results which Haber published in 1905 for the ammonia equilibrium. This was probably fortunate, for a very spirited controversy now arose over the exact nature of this equilibrium. It was Nernst's opinion that the errors involved in measuring the very small quantity of ammonia which Haber had found at ordinary pressures were large, and that consequently too much reliance ought not to be placed on his results. It was generally recognized that more ammonia could be obtained at increased pressures, so Nernst undertook the investigation at elevated pressures where the errors would be less—certainly so far as the estimation of ammonia was concerned. Very soon, thereafter, Haber also began work at higher pressures, selecting 30 atmospheres for the larger part of his experiments. For our present purpose, there is no occasion for a detailed discussion of these investigations. It is sufficient to state that the outcome resulted in a fairly equitable division of honors. Nernst is now usually credited with being the first to have synthesized ammonia under pressure, while Haber's final equilibrium data, obtained at 30 atmospheres, have been generally accepted for this reaction. Other experimenters, since that time, have extended Haber's equilibrium data to pressures as high as 1000 atmospheres. Some of this data is reproduced in Table I. It will be noted that the results are in complete agreement with Le Chatelier's principle referred to above, namely, that the equilibrium amount of ammonia decreases with increase in temperature and increases with increase in pressure.

TABLE I. PERCENTAGE OF AMMONIA AT EQUILIBRIUM

Temp. °C.	Pressure (atm. abs.) 1	50	100	300	1000
200	15.3	74.38	81.54	89.94	98.29
300	2.18	39.41	52.04	70.96	92.55
400	0.44	15.27	25.12	47.00	79.82
500	.13	5.56	10.61	26.44	57.47
600	.05	2.25	4.52	13.77	31.43
700	.02	1.05	2.18	7.28	12.87

Although the equilibrium data obtained by Haber showed that the commercial synthesis of ammonia was a possibility, even at pressures as low as one atmosphere, the determining factor was still the catalyst. The *rate* of ammonia formation was fully as important as the equilibrium amount which might be produced. Haber, accordingly, turned his attention to the study of catalysts. Although this work produced no catalysts of industrial value, it did serve to convince Haber that the technical operation of the synthetic ammonia process would probably require temperatures in excess of 500°C., since he had found no catalysts which showed any appreciable activity at temperatures below this. It was Haber's opinion furthermore that in any industrial application of the direct synthetic ammonia process,

the catalyst must be capable of producing rapidly at least 5 per cent of ammonia. From his equilibrium data and other considerations, Haber fixed 100 atmospheres as the minimum pressure which he believed to be technically feasible. Since that time, however, catalysts have been developed which are active below 500°C. and which permit operation of the synthesis process at pressures below 100 atmospheres.

Because of the increased concentrations which follow compression of the nitrogen-hydrogen gas mixture, one would expect a progressive increase in the rate with which ammonia is formed as the pressure is increased. In fact, Le Chatelier believed that there was basis for assuming that a pressure might be reached where the reaction would proceed with appreciable rapidity even in the absence of a catalyst. Strangely enough, many catalysts appear to balk at the application of higher pressures. As a consequence, the increased acceleration which might be expected to follow an increase in pressure has not been fully realized. It may have been considerations such as these which led Haber and also the Badische Anilin- und Soda-Fabrik, which industrialized Haber's process, to disregard pressures in excess of 250 atmospheres. In recent years, however, catalysts have been developed which do not suffer such a loss in activity when the pressure of the reacting gases is increased, so that considerably higher pressures than those employed by Haber are now commercially feasible.

The exact nature of the catalysts which have been developed in the various adaptations of the direct synthetic process, particularly in Europe, has been carefully guarded. Their general nature, however, is pretty well known as a result of experimental work carried on in this country. The main constituent of these catalysts is undoubtedly iron prepared by reducing an oxide of iron. The reduction product of pure iron oxide is practically valueless, however, because of the rapidity with which it loses its activity. . A simple explanation for this loss in catalytic action may be a gradual sintering or coalescing of the porous iron formed during the reduction of the oxide. This sintering may be appreciably retarded, however, and the properties of iron otherwise favorably modified by the addition of relatively small amounts of certain metallic oxides. Thus, for example, an oxide of aluminum has been found to preserve, or as is more generally designated, to "promote" the catalytic action of the iron.. The most active iron catalysts now generally known employ promoters which are essentially compounds or mixtures consisting of one or more oxides having acidic properties and one or more oxides having basic properties. Thus, for example, a mixture of potassium oxide and aluminum oxide or potassium aluminate added to iron oxide yields a highly reactive catalyst even at temperatures as low as 450°C. For commercial use, iron catalysts are prepared by melting Fe_3O_4 (magnetite), adding the desired pro-

moter to the molten oxide, allowing the fused mass to cool, breaking it into fragments of suitable size, and finally reducing it in hydrogen.

Although ammonia catalysts in which iron is the principal constituent differ markedly in their catalytic action, they are all most exacting so far as the quality of the reacting nitrogen-hydrogen gas mixture is concerned. The impurities usually present in nitrogen-hydrogen mixtures made by any of the common commercial methods are compounds of sulfur and of oxygen. Compounds of sulfur must be removed completely; otherwise the catalyst becomes progressively less active and finally completely inactive. Oxygen or compounds of oxygen, such as water vapor, carbon monoxide or carbon dioxide, produce a lowering in the activity of the catalyst even at concentrations as low as 0.001 per cent. The complete removal of oxygen or its compounds is not so essential, however, so far as the life of the catalyst is concerned, for there is no complete destruction of the catalytic activity—simply a diminution, the extent of which is, within certain limits, proportional to the oxygen concentration. There are limits, however, which the concentration of oxygen or of its compounds must not exceed if an appreciable synthesis is to be accomplished. When it is remembered that approximately 100,000 cubic feet of gas are required for each ton of ammonia produced, it is evident that a substantial part of the cost of ammonia by the synthetic process is involved in the gas purification.

Various methods have been employed for preparing nitrogen-hydrogen mixtures suitable for ammonia synthesis. For example, nitrogen may be extracted from the air by fractional distillation of liquid air. Usually, however, the oxygen is separated from the nitrogen by some chemical method, either by combining the oxygen with hydrogen to form water or with carbon to form carbon monoxide or carbon dioxide. When air is blown through hot coke, a gas mixture is formed which consists largely of nitrogen and carbon monoxide. This method of removing oxygen from the air is known technically as the producer-gas process. It is only employed in conjunction with the water-gas method of producing hydrogen described below. Both producer gas and water gas contain relatively large quantities of carbon monoxide and, consequently, involve similar methods of gas purification which can advantageously be applied to the mixed gases.

Practically all the hydrogen employed in the direct synthesis of ammonia is obtained from water, either by electrolysis or by reaction with certain reducing agents, the most common of which is carbon. Electrolysis produces hydrogen which is readily purified but the method cannot be economically employed except in a few favored localities where electric power is very cheap. Some electro-chemical processes produce hydrogen as a by-product which, of course, may be used in the synthesis of ammonia. The

electrolytic production of alkalis and of chlorine is typical. By far the greater part of the hydrogen for ammonia synthesis is produced today by the decomposition of steam in contact with hot carbon, the so-called water-gas process. This process produces a gas containing approximately 50 per cent hydrogen and 50 per cent carbon monoxide. The carbon monoxide may be separated from the hydrogen by liquefaction or may be made to react with more steam to form additional hydrogen. When the latter method is employed, it is necessary to use a catalyst. This is usually an oxide of iron, which accelerates this reaction in the neighborhood of 500°C. and at ordinary pressures. If producer gas has been added to the water gas, the gas mixture resulting from this catalysis contains about 30 per cent of carbon dioxide, 3 per cent carbon monoxide, and the remainder nitrogen and hydrogen.

The production of hydrogen by the water-gas process necessitates the removal of large quantities of carbon dioxide. The greater portion of this gas may be removed by solution in water. Its solubility at ordinary pressures is relatively low, however, so that this operation must be carried out at elevated pressures. In the German plants, a pressure of 50 atmospheres is employed for this purpose. Scrubbing with water does not completely remove the carbon dioxide nor does it remove any appreciable amount of carbon monoxide. These may be removed by scrubbing the gases first in caustic and then in an ammoniacal solution of certain copper salts. These copper solutions remove the last traces of carbon dioxide, also the carbon monoxide, together with any oxygen which may have been present in the gas. The complete removal of the oxides of carbon may also be accomplished catalytically, methane and water being formed. When this method is employed, no attempt is made to remove the methane from the gas since it does not poison the ammonia synthesis catalyst. In some technical adaptations of the synthetic ammonia process, the final step in the purification process involves the removal of water vapor.

With a relatively pure nitrogen-hydrogen gas mixture available, the synthesis operation consists essentially in compressing the gas and passing it through a reaction vessel capable of withstanding the operating pressure and temperature. This vessel contains the catalyst and also a means for bringing the gases to the temperature at which the reaction occurs. Considerable heat is evolved when ammonia is formed, which is utilized so far as possible to bring the incoming gas mixture to the temperature of the catalyst. This exchange of heat between the hot and the cold gases is often accomplished—in part, at least—in a separate pressure-sustaining vessel specially designed for that purpose.

In all the processes operated today, the percentage of uncombined gas is so high that this must be recovered and again subjected to the action of

the catalyst. This necessitates the removal of ammonia while the gases are under pressure. This is usually accomplished either by cooling the gas to a temperature where liquid ammonia condenses or by scrubbing the gas with water. It is evident that the number of times which a given gas mixture must be brought into contact with a catalyst in order to convert it largely into ammonia will depend upon the fraction converted during each passage. For example, if the net conversion is 10 per cent during each contact with the catalyst, the operation must be repeated about fifteen times if there is to be no appreciable waste of nitrogen-hydrogen. When, however, the net conversion is 40 per cent, the operation need be repeated but five times; while a conversion of 75 per cent would make two such operations sufficient.

The Haber process, developed in Germany, differs markedly from the Claude process, developed in France, in regard to the means for bringing the uncombined gases repeatedly into contact with the catalyst. The German plant operates at 250 atmospheres' pressure and under such other conditions that the conversion to ammonia is less than 10 per cent. In these plants, a single reaction vessel is employed through which the gases are repeatedly passed by means of a circulating pump. The ammonia formed in the reaction vessel is removed by solution in water. In certain other adaptations of the process, the ammonia is removed by cooling the gases to temperatures where it condenses. Claude, on the other hand, has developed the process to operate at pressures where the conversion is about 40 per cent. So, instead of circulating the gas through a single reaction vessel, he finds it advantageous to employ a number of synthesis units placed in series, the ammonia formed in each being removed by cooling the gas before its passage to the next member of the series. So far as the catalytic operation is concerned, there is, of course, no reason why the circulatory method cannot be operated at the high pressures which are employed by Claude. In fact, this has been done in the Italian development of the process by Casale.

It is impossible in the space allotted to this paper to discuss all the factors which have influenced the technical development of the direct synthetic ammonia process. For example, there is the matter of steel tubing and vessels capable of withstanding the high pressures and temperatures involved in this process. The physical properties of the compressed gases have also developed new and unexpected problems in gas purification and heat transfer. Careful control of gas composition, rate of flow, temperature—all these are very essential to the successful operation of the process. These various problems have all found some solution, so that there are now no serious obstacles to the commercial adaptation of this nitrogen fixation process. It is, at present, our best assurance that there will always be an adequate nitrogen supply.

THE WORK OF THE BUREAU OF STANDARDS ON RUBBER*

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The work on rubber at the Bureau of Standards began in December, 1905, with the analysis of a sample of cable insulation. No more samples of rubber were received until July, 1908, since which time the interest of the Bureau in the subject has continued and increased. Now, as for some years past, its work on rubber falls into four main groups: Routine Testing, Special Testing, Research, and Specifications.

Routine Testing

Practically all of this testing is done for Government departments in connection with the purchase of all kinds of rubber goods, in order to find out whether deliveries comply with the requirements of the specifications or, where there are no specifications, in order to select the best goods. The word "routine" in this connection should not be understood to imply that the tests are hurriedly made in a mechanical fashion. That is far from being the case, because even the simplest chemical analysis or physical test requires careful and conscientious attention to details. It is routine only in the sense of being a never-ceasing activity. Because of the time and thought devoted to this testing, the Bureau has seen the need for improved methods and has been successful in developing several of them.

Among the hundreds of samples tested and analyzed each year are many kinds of hose, hospital supplies, automobile tires and inner tubes, insulation, and asbestos and other packings. These represent Government contracts running into millions of dollars.

The testing at the Bureau led to requests for information about the methods used. This demand was met by issuing Circular 38, "Testing of Mechanical Rubber Goods," in 1912. From 38 pages this has grown to 127 in three successive revisions. The fourth edition, now called "Testing of Rubber Goods," appeared in 1921 and is before long to be superseded by a fifth edition.

The Bureau has published methods for the determination of sulfur, barium carbonate, free carbon, cellulose, and antimony, for rubber by combustion of the nitrosite, for rubber and mineral matter by solution in mineral oil, and for the detection of glue.

The rubber industry seems to think well of the methods and apparatus developed by the Bureau for making physical tests, and the American Chemical Society and the American Society for Testing Materials adopted the Bureau's procedure for chemical analysis with but a few changes. Our representative coöperated in working out the special methods of the Joint Rubber Insulation Committee.

* Published by permission of the Director, Bureau of Standards, Department of Commerce.

Special Testing

The Bureau rarely makes chemical analyses for the public, because of the amount of testing that must be done for Government departments and because of a reluctance to compete with commercial analysts. However, from time to time, when circumstances permit, the Bureau coöperates, particularly with tire manufacturers, to find out the effect of some proposed change in the rubber compound, of a different type of cotton cord, or of a new design of tread upon the serviceability of the tire. It must be remembered that a tire is not simply an inert bag of air, but a mechanical structure of several coördinated parts, each serving a purpose and all working together. How well they work together has much to do with the comfort of the rider, the life of the tire, and even the mileage per gallon of gasoline.

Research

Much of the research in the chemical laboratory has to do with analytical methods, as new ones are needed from time to time. When the first sample of rubber was analyzed by the Bureau in 1905, all that was asked for, and all that was deemed necessary, was the determination of sulfur, acetone extract, and ash, with rubber by difference. Nowadays in the light of better knowledge the rubber chemist or technologist is not satisfied with the meager information gained by such an analysis. He knows, too, that the method then employed for sulfur is not accurate and that only in rare cases can the amount of mineral matter be determined correctly by ignition. He wants to know the amount of free sulfur, of carbon, glue, antimony, rubber substitutes, and other ingredients, and the amount and character of the mineral matter actually used, and not the constituents of the ash. Today there are quite satisfactory ways of determining all of these, but there is still a need for some means of finding out how much reclaimed rubber has been used in a compound, and a short and convenient method for the direct determination of rubber. Treatment of the rubber with "nitrous fumes" and combustion of the resulting nitrosite gives accurate results, but the procedure is roundabout, tedious and inconvenient. We must still determine rubber by difference, hoping that the result will not be too far from the truth.

About four years ago the Bureau started, and is still continuing, an investigation on the power losses in tires. It was thought that losses by internal friction must have a very direct relation to the life of a tire. That this is true has been demonstrated by dynamometer tests. Other things being equal, the life of a tire can be increased by reducing internal friction. The detailed results of this investigation have been published in three *Technologic Papers* of the Bureau.

Considerable time has been devoted to a study of the wear of rubber

compounds, to determine, if possible, why it is that some are more resistant than others. Some years ago the Bureau entered upon an extensive series of experiments to develop an accelerated performance test for tires with the aid of which it would be possible to predict their relative durability, instead of depending upon the usual time-consuming road tests. This investigation was brought to a successful conclusion with the aid of the Rubber Association. The endurance machines of the Bureau are now running night and day, testing tires bought on Government contracts or those of regular and special designs submitted by manufacturers.

Perhaps the most pressing problem of the rubber industry today is the aging of rubber. Everybody knows that rubber loses its life sooner or later. The change in physical properties from a tough, elastic substance to a dull, lifeless, and finally brittle mass is accompanied by chemical changes as well. The most striking is the increase in the percentage of acetone-soluble matter. This is commonly believed to be a result of oxidation, yet we know that this is not the complete explanation. Every chemist knows that tubing and stoppers which are in frequent use last longer than those which are kept undisturbed in stock, though all were originally alike in composition. A difference in the effect of atmospheric oxygen may seem an adequate reason why one box of rubber bands is useless in a year or two, while those from a different maker retain their elasticity for eight or ten years. It is easy to say that the best bands contain or lack something which causes them to resist oxidation, but such an explanation fails to show why tubing kept in use has the longer life.

In spite of this discrepancy between theory and observation most of the published accelerated aging tests for rubber are based upon its oxidation at an elevated temperature, sometimes in the air, sometimes in oxygen under pressure. There is no doubt that oxygen plays a leading part in the destruction of rubber, yet evidence is being accumulated to show that light, with oxygen almost completely excluded, will cause the deterioration of rubber. This should not be too surprising when we consider that rubber is a complex colloidal system, and must share to some extent the sensitiveness of such systems as a class.

The ultimate object of making accelerated aging tests is to find out how and why rubber deteriorates, and how its loss of desirable properties can be avoided or postponed. It has been found elsewhere that a small amount of some easily oxidizable substance, for instance, hydroquinol, added to the rubber compound will greatly increase its resistance to oxidation by acting as a negative catalyst. The use of this or other anti-oxidants is rapidly increasing.

For many years guttapercha has been almost the only insulating material used in submarine cables. The supply of this is small in comparison with rubber, and it is tending to become much smaller because the trees are de-

stroyed to obtain the gum, and no attempt has been made to cultivate them. There would seem to be no good reason why properly compounded rubber should not have as good dielectric and other physical properties as gutta-percha. For a few years the Bureau has been making an investigation of the possibilities of rubber for submarine cable insulation. If the laboratory problem is solved, its transfer to the plant should be easy, because the technic of handling rubber is far better known than that of gutta-percha.

Specifications

For years the Government departments were in the habit of buying supplies of all kinds "on price" or "on sample," each procedure having obvious disadvantages. Here and there were sporadic specifications, and in some cases two or three quite different ones for the same grade of material. It was a great step forward when the General Supply Committee was organized in 1909 to make annual contracts for the departments. A greater step was the formation of the Federal Specifications Board in 1921, under the *ex officio* chairmanship of the Director of the Bureau of Standards. Among the technical committees named by the Board to prepare specifications, one of the earliest was the Committee on Rubber, its chairman a member of the Bureau's staff. To date the committee has written between sixty and seventy specifications which have been promulgated by the Board. These cover various kinds of hose, tires, hospital supplies, and other rubber goods, as well as several kinds of rubber asbestos and other packings. Other specifications are being prepared. It goes without saying that the records of hundreds of tests made by the Bureau and its facilities for doing special work when needed, proved invaluable to the committee in writing the specifications. The committee work has reacted to the benefit of those in the rubber laboratories because they have been under the necessity of putting into concrete form the results of their experience, and of having their specifications scrutinized by the rubber industry's representatives, who have not been slow to point out requirements that are too strict or are superfluous.

Some of the sixty or more specifications have been published as Circulars, and the rest are at present available only in mimeographed form. The papers on analytical methods include two Scientific Papers and fifteen or more Technologic Papers, as well as a few journal articles that have not been published by the Bureau. Several of the Scientific and Technologic Papers were also published in chemical journals.

The Education of the Rubber Chemist

Among the numerous chemists who have worked in the rubber laboratory of the Bureau, not one had been educated specifically to be a rubber chemist. Only a few had had any experience with rubber before coming

to the Bureau. Some who came directly from high school had the ability and energy to make good, and they supplemented their school training by taking college courses evenings. The best of all the chemists had graduated from colleges where they had received a good, all-around training in chemistry. Nothing better than that can be suggested for the chemist who intends to specialize in any branch of chemistry. The rubber analyst, if he is to employ existing methods intelligently or devise new ones, must know more than the mechanical technic of safely transferring a precipitate to a filter paper and finally igniting it.

Development of New Quick-Drying Finish Explained by Dr. Stine. The progress of chemical research in developing a new finish for domestic purposes was explained before the Ontario Retail Hardware Association for the first time by Dr. Charles M. A. Stine, director of chemical research of the du Pont Company, under whose direction the Duco finish for automobiles, furniture, and industrial uses was developed and perfected. Dr. Stine, who is recognized as one of the leading industrial research chemists in the United States, told the story of the creation of a quick drying finish which can be brushed to produce a film which would be "durable, waterproof, tough, hard, elastic, have good adhesion to the surfaces to which it is applied, which would have no tendency to lift off the old paint and varnish surfaces, which would have good gloss and hiding power and above all, be fast drying."

After years of painstaking research and a background of experience in which each ingredient had to be originated, perfected, and made chemically pure, Dr. Stine declared that the product developed was certain to have a ready market because of the domestic needs which it would serve.

Unlike paints, varnishes, and enamels this new product is made from nitro cellulose. "Cotton linters," said Dr. Stine, "are obtained from the cottonseed mills. Before nitration all impurities have to be removed. This purification begins with the digestion with chemicals under pressure, followed by bleaching treatments and a long series of washings to remove all traces of the chemicals used. The next step in the manufacture is the nitration of the cotton. The nitrated cotton is then boiled, with frequent changes of water, until exceedingly delicate chemical tests show that the pyroxylin has attained a chemical stability sufficient to insure extremely long life of products made from it.

"After some years of experimentation, we fortunately hit upon a good workable method for the treatment of pyroxylin which enables us to produce pyroxylin solutions with the necessary content of pyroxylin so that these more concentrated solutions deposited much thicker films upon evaporation. They yielded finishes which showed a good build."

Dr. Stine, in explaining each stage of the research development told of the experiments to produce the requisite brushing properties, of the concentration of the solutions and development of chemically pure pigments and of the accurate control of every step in the manufacture in order that the finished formula, when applied to furniture, floors, walls, or any household use, would deposit an odorless, as well as a fireproof film which would outlast any finish product ever developed before, while at the same time having the polish and gloss of ancient lacquers.

Thus, chemical research created a new product for home use out of substances which had never been used before and possessing qualities which satisfied home needs.

AN EXPERIMENTAL STUDY OF METHODS FOR RECORDING LABORATORY NOTES IN HIGH-SCHOOL CHEMISTRY

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The Problem

The note-book problem has been and continues to be a perplexing one for teachers of high-school chemistry. A great many articles appear in the literature on chemical education concerning the best methods to use in recording notes, but practically all of the articles are based on the personal opinion of the individual writer and not on statistical evidence. A careful survey shows that the chief difference of opinion seems to be in regard to the advisability of requiring the student to write down the procedure or method followed.

A few typical examples will show this difference. Bulletin No. 26 of the Bureau of Education on "Reorganization of Science in Secondary Schools," page 39, says, "Flexibility in the keeping of notes is desirable provided the essential facts and conclusions are always included. The notes should usually include a clear statement of the problem at hand, a description of method of procedure—a statement of results and conclusions." U. C. Greer[1] states, "The best work is done when the student writes a simple but full exposition of the important features of the experiment with whatever conclusions to be derived therefrom and renders it in clear English." Rowell[2] expresses virtually the same opinion.

Conversely, J. Mathews[3] states, "The requirement of written descriptions is one that can stand a great amount of introspective scrutiny."

The so-called "loose-leaf" manual has appeared in recent years and has secured wide adoption. This type of manual is supported by various writers. For example, John H. Dahl[4] advocates the use of loose-leaf sheets, with space for answers to be given in monosyllables or very brief statements. Elliott[5] also advocates the exclusive use of loose-leaf note-books. Charles E. Dull in the preface to his "Laboratory Exercises in Chemistry," says, "The average student spends too much of his laboratory time writing a record of his experiment—as an aid to English drill, this part of the exercise (*i. e.*, recording of method) is considered to be quite worthless—as an aid to the memory, its value is deemed very small."

In view of the various differing opinions and the constant problem which the note-book presents, the writer decided to undertake an experimental investigation, in the hope of arriving at some definite conclusions regarding the best method to use for note-book write-ups.

[1] *Sch. Rev.*, **14**, 282–96 (1906).
[2] *Sch. Sci. Math.*, **19**, 525–6 (1919).
[3] *Ibid.*, **16**, 767–8 (1916).
[4] *Ibid.*, **19**, 162–3 (1919).
[5] *Ibid.*, **17**, 745–6 (1917).

General Method Followed

The writer first obtained a representative number of the laboratory manuals and loose-leaf note-books in use in high schools at the present time. These were then carefully examined in order to determine, if possible, the method advocated by the author for recording the notes.

It was found that the methods advocated could be divided into three general groups. Some of the manuals were rather indefinite in regard to the method given but if the general make-up of the manual suggested strongly that it belonged to one of the divisions it was placed there. The following are the three forms commonly used:

Form 1

Write the notes according to: (1) what you did, (2) what you observed, (3) what conclusions you drew. Answer the direct questions in the manual.

Form 2

Write the notes according to: (1) title, (2) materials used, (3) object, (4) procedure, (5) results, (6) conclusions. Answer the direct questions in the manual.

Form 3

Answer the questions given with each experiment in the blank spaces provided in the manual, or if these are not provided, in a separate note-book.

Eight manuals were examined which advocated Form 3 and all but two are published in loose-leaf form. One-word answers are asked for, in part, by some of these manuals but all require a great many answers in complete sentence form, so this difference is not great. None of the manuals of this group ask questions which require the pupil to record what he has done (*i. e.*, procedure). For the most part these manuals ask questions concerning only: (1) what was observed, (2) conclusions, based on observations, (3) completion or writing of equations.

Five manuals were examined which advocated Form 1, while two were found which advocated Form 2, making in all fifteen high-school manuals which were examined. Since the manuals examined include a very large percentage of those in use, it is safe to say that the three forms given are the ones most commonly used by the high-school students of this country. This is especially true because the average teacher usually follows the suggestions given by the author of the manual used.

Method Followed

Since the three forms for recording notes which have been given are the ones in common use, it seemed logical that each method should be tried out experimentally, in order to determine, if possible, the best method to use.

The pupils of the Preparatory Chemistry Class of The Athens School, University of Chattanooga, were used as subjects. The first step taken was to divide the class into two groups of as near the same intelligence and ability as possible. The twenty-four members of the class were given the Otis Group Intelligence Test, Form A, and the Terman Group Intelligence Test, Form A. The following table gives the data for both groups, one of which is called Group A and the other Group B.

		Group A	Group B
1.	Average total intelligence score	126.3	125.0
2.	Average past school grade	B	B
3.	Average age in years	18.48	18.43

Three investigations were carried out. In Investigation I, Group A used the method of recording notes given in Form 3, namely filling in the blanks and answering the questions in the spaces provided in the manual. Group B wrote their notes according to Form 2: (1) title, (2) materials, (3) object, (4) procedure, (5) results, (6) conclusions, answering the direct questions. Ten tests covering fifteen experiments were given during this investigation. During the course of Investigation II, Group A (which had filled in blanks during the first investigation) was asked to record notes according to Form 1: (1) what you did, (2) what you observed, (3) what conclusions you drew; answer the direct questions. Group B (which had used the detailed write-up before) used Form 3 and answered the questions given with each experiment in the blank spaces of the manual. Seventeen experiments and tests were used during this investigation. During Investigation III both groups used Form 3 and filled in the blank spaces only. This last investigation was undertaken to obtain a comparison of the scores of the two groups when using the same method for recording notes. Results from Investigation III furnish a further check on the relative abilities of the two groups. Ten tests and ten experiments were used in this investigation.

In order that the method of writing notes should be the only factor in which the groups differed in instruction, the following precautions were taken: (1) Both groups were given exactly the same directions for doing each experiment. (2) Both groups performed the same experiment at the same time. (3) All writing of notes was done in the laboratory. (4) No manuals or note-books were allowed to leave the laboratory. (5) Both groups met together for class-room instruction. (6) No diagrams or drawings were made by either group.

The following method was used in testing results: One week from the date on which the experiment was performed, both groups were given a test covering the experiment involved. Approximately one month after the experiment had been performed, the same tests were given again.

The questions were framed so as to permit the marking of a question

either right or wrong. No partial credits were given. This plan was used to avoid the human factor in grading the tests. The experiments given for the most part were taken from "Laboratory Exercises to Accompany Elementary Principles of Chemistry" by Brownlee and others (Allyn and Bacon, 1921). Each student of Group A was paired with another student of Group B, of approximately equal intelligence and ability. In case any student was absent at the time a test was given, the grade of the other member of the pair was also omitted from the record.

General Summary of Results*

The results obtained during the three investigations may be summarized briefly. In Investigation I the students of Group B, who used the detailed write-up given in Form 2, made an average of 4.24 per cent better scores, after one week, than did the students of Group A who filled in the blank spaces of the manual only (Form 3). Group B also ranked 7.94 per cent higher on these same tests when given one month after the experiments were performed.

The results of Investigation II show that the students of Group A who wrote their notes according to the form (1) what you did, (2) what you observed, (3) what conclusions you drew; answer the direct questions (Form 1), ranked 3.83 per cent higher after one week than did the students of Group B who filled in the blank spaces of the manual (Form 3). Group B, however, averaged 1.91 per cent higher when the tests were given one month later.

The results of Investigation III show that Group A ranked 0.66 per cent higher after one week and 1.19 per cent higher after one month. This gives further proof that the two groups of students were as equal in ability as it was possible to group them and that any appreciable difference in scores must be due to the method employed in recording the notes.

The method of using a separate note-book, with a description of the method followed in the experiment, gave somewhat better results in both the first and second investigations, so far as temporary results were concerned. The detailed write-up required by Form 2 gave better results after one month and evidently aided retention to some extent. The briefer method required by Form 1 gave no better results than merely filling in the blank spaces of the manual (Form 3), so far as retention was concerned.

Conclusions

The following general conclusions seem to be justified by the results obtained:

* The tests given together with the complete tables of results and graphs can be found in "An Experimental Study of Methods for Recording Laboratory Notes in High-School Chemistry," a Master's Thesis, unpublished, University of Chicago Library.

(1) The method of using a separate note-book with a write-up including the procedure followed, gives slightly better temporary results.

(2) The writing of the procedure or method followed does not appreciably aid the memory in retaining the main facts of the experiment.

(3) The many extra hours needed by the students to write separate detailed notes and by the instructor to correct them are probably not justified by the results obtained.

(4) The use of loose-leaf manuals provided with blank spaces to be filled in by the student during the course of the experiment are economical as time savers to both teacher and pupil. This type of manual has the further advantage of giving results nearly as good as when a separate note-book is used.

(5) If separate note-books are used, they should contain only a brief statement of the object of the experiment and the answers to the questions given in the manual.

(6) The conclusions reached do not mean that students should not know and be able to explain experimental methods. Students need to realize the importance of proper experimental details and should be able to explain the significance of each step taken during the course of an experiment. The pupil must understand the experiment and know the important facts which it brings out before he can answer correctly the questions given in the better class of manuals. However, a mere copying of methods, which are given in print, or even recording these in the student's own words, did not appreciably aid the students investigated in grasping the main points of the experiment and for them it seemed largely a waste of time.

(7) It is realized that the conclusions reached as a result of this study must be accepted as tentative, because of the fact that the number of subjects used was small. The author expects to undertake further investigations of a similar nature and it is hoped that other teachers of science will do likewise. When this is done permanent conclusions may be drawn.

NEW TEACHERS' MAGAZINE APPEARS

The faculty of the Colorado State Teachers' College has established a new teachers' magazine to appear monthly during nine months of each year. *The Teachers' Journal and Abstract* is intended to function not as one more addition to the already large number of educational magazines but as a time-saver for the busy teacher who cannot possibly keep abreast of all the current literature. Its abstract service is, therefore, the outstanding feature. It includes, however, a number of original articles each month. Another helpful feature is the publication of bibliographies on various phases of educational work.

The initial copy (January, 1926), now on our desk, shows every promise of a journal of much worth. We congratulate the faculty of the Colorado State Teachers' College upon their efforts and wish them continued success in the future.

SEPARATE CLASSES IN FRESHMAN CHEMISTRY FOR PUPILS WHO PRESENT HIGH-SCHOOL CREDITS IN CHEMISTRY

F. E. BROWN, IOWA STATE COLLEGE, AMES, IOWA

The pupils who present themselves to a teacher of freshman chemistry vary widely in ability and previous scientific training. The same freshman class will include the weak student who offers music and typewriting and as little science as possible for entrance credits, and the strong student who took, during his preparatory course, all of the mathematics, physics, and chemistry which his school offered. Some college teachers have been so bewildered by such a range of abilities that they have discouraged the teaching of their subjects in high school and have advocated high-school physics or mathematics as the best preparation for college chemistry. Many college teachers ignore the high-school training of their pupils and proceed on the theory that all of the subject must be taught to all pupils regardless of what was done in high school. Such a procedure is discouraging to both pupils and teachers in high schools, and actually increases the difficulties in making high schools the efficient developers of young minds, which they should be.

Recently, Harry Shipley Fry[1] has summarized the objections to the recognition of high-school chemistry by colleges. He believes that students who have spent 200 hours with a high-school chemistry teacher can be put in a class with pupils who have had no chemistry, and a course in general chemistry presented so that neither group is subjected to any hardship, when the course is presented in about 200 hours. He presents data from such classes to show that the grades for pupils who have had high-school chemistry are but little better than the grades for those who had no high-school chemistry. The problem at Iowa State College is more serious than at the University of Cincinnati because we have but 144 hours (including laboratory) of contact with our pupils in freshman inorganic chemistry. It does not seem reasonable that pupils with 200 or more hours in contact with a high-school instructor in chemistry, should require anywhere near the effort to learn any reasonable assignment designed for 144 hours of lecture, recitation, and laboratory that would be required of pupils who had never studied chemistry at all. So, though our experience with freshman sections composed of pupils who have had and of pupils who have not had high-school chemistry corresponds in general to that of Fry, we have conducted a class for men who have had high-school chemistry, separate from the class for those who have not had high-school chemistry. It is obvious that grades made in these two classes cannot be compared; for the intention is to make the courses equally difficult for the respective groups, but a comparison can be made in the more advanced

[1] THIS JOURNAL, 2, 260–9 (1925).

courses in chemistry where these pupils are reciting together. In these classes the pupils meet a set of instructors who know nothing of their high-school work or lack of it. The instructors are interested only in the pupils' ability to do work in qualitative analysis, quantitative analysis, organic chemistry, advanced inorganic chemistry, or special courses required for technical students.

Nearly all of the courses in college require one quarter of qualitative analysis. In about four years covered by our data, 2330 pupils have taken our beginning chemistry in the classes divided on the basis of entrance credits in high-school chemistry and later have also completed the course in qualitative analysis. Of these, 548 had taken high-school chemistry and 1782 had not taken such a course. The distribution of grades in qualitative analysis is shown in Table I.

TABLE I

Grades	Number of pupils		Per cent of pupils	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
95–100	20	23	3.65	1.29
90–94	83	152	15.14	8.53
85–89	108	318	19.71	17.85
80–84	148	533	27.01	29.91
75–79	131	507	23.90	28.45
C	34	144	6.21	8.08
N. P.	24	105	4.38	5.89

C indicates condition and N. P. indicates failure.

Students from these divided classes enrolled in 1108 quarters of applied organic chemistry. Two hundred fifty-three quarters were taken by pupils who had credits in high-school chemistry, and 855 quarters by pupils who had no credit in high-school chemistry. The distribution of grades in applied organic chemistry is shown in Table II.

TABLE II

Grades	Number of pupils		Per cent of pupils	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
95–100	9	39	3.56	4.56
90–94	48	106	18.97	12.40
85–89	79	196	31.23	22.93
80–84	57	228	22.53	26.67
75–79	46	232	18.18	27.13
C	9	36	3.56	4.21
N. P.	5	18	1.97	2.10

Students from these divided classes enrolled in 912 quarters of quantitative analysis. Of these, 297 quarters were taken by students who presented high-school credits in chemistry and 615 quarters by students who did not present high-school credits in chemistry. The distribution of grades in quantitative analysis is shown in Table III.

TABLE III

Grades	Number of pupils		Per cent of pupils	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
95–100	16	17	5.39	2.76
90–94	51	89	17.17	14.47
85–89	73	145	24.58	23.58
80–84	75	161	25.25	26.18
75–79	56	143	18.85	23.25
C	22	49	7.41	7.97
N. P.	4	11	1.35	1.79

Pupils from these divided classes were enrolled for 332 quarters of other advanced work in undergraduate chemistry. One hundred fifty-one of these enrolments were made by pupils who presentedc redits in high-school chemistry and 181 enrolments by those who presented no credits in high-school chemistry. The distribution of grades is shown in Table IV.

TABLE IV

Grades	Number of pupils		Per cent of pupils	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
95–100	3	6	1.99	3.31
90–94	14	22	9.27	12.15
85–89	45	35	29.80	19.34
80–84	44	43	29.14	23.76
75–79	31	48	20.53	26.52
C	10	25	6.62	13.81
N. P.	4	2	2.65	1.11

Anyone who has graded the work of pupils knows the difficulty in making exact numerical evaluations of ability or of interpreting numerical grades. But, in a system where 100 is perfect, 75 is passing, and below 60 is failure, a grade of 85 would be approximately the grade which would separate good students from mediocre and poor students.

Table V is a summary of all undergraduate grades in chemistry made by our pupils since we have taught those who presented high-school credits in separate classes, arranged to show the effect of high-school chemistry and separate classes on the probability of receiving grades of 85 per cent or better in subsequent courses in chemistry.

TABLE V

Courses	Per cent of pupils below 85%		Per cent of pupils 85% or above	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
Qual. Anal.	61.50	72.33	38.50	27.67
Applied Org.	46.24	60.11	53.76	39.89
Quant. Anal.	52.86	59.19	47.14	40.81
Other Adv. Chem.	58.94	65.20	41.06	34.80

Men who have taken freshman general chemistry in classes divided on the basis of chemistry credits offered for entrance to college, have enrolled in 4782 quarters of undergraduate chemistry in advance of their general

chemistry. Of these, 1249 quarters of work were taken by those who had offered high-school chemistry as an entrance credit and 3433 were taken by those who had not offered high-school chemistry credits. The distribution of grades for all of these enrolments is given in Table VI.

TABLE VI

Grade	Number of pupils		Per cent of pupils	
	H. S. Chem.	No H. S. Chem.	H. S. Chem.	No H. S. Chem.
95–100	48	85	3.84	2.48
90–94	196	369	15.69	10.75
85–89	305	694	24.42	20.21
80–84	324	965	25.94	28.11
75–79	264	930	21.24	27.09
C	75	254	6.01	7.40
N. P.	37	136	2.96	3.96

It will be seen that 43.95 per cent of the grades made by pupils who offered credits in high-school chemistry are above 85 per cent while only 33.44 per cent of the grades made by those who did not offer credits in high-school chemistry are above 85 per cent.

There are two imperfections in these data. Neither of them can have any material effect on the conclusions which we shall attempt to draw from the data but they should be noted. First, there are a few students who have taken high-school chemistry and have begun their college work during the winter quarter or the spring quarter. We do not have a separate class for them and they recite with those who have taken no high-school chemistry. Their subsequent grades, also, are credited to those who did not take high-school chemistry. Second, several squads of instructors collected these data from the permanent record cards. Each squad took a drawer full of cards arranged alphabetically and culled the data from it for both types of students. Too late to rectify the discrepancy it was found that some squads had noted only the final grade in each subject and disregarded C's or N. P.'s which had been removed by subsequent work. The comparison between those who did take and those who did not take high-school chemistry could not be materially affected by this, but no conclusion with regard to the absolute percentage of failures and conditions in our courses is justified.

Discussion

A homogeneous body of students is much easier to teach than a body composed of students of widely varying abilities. The mastering of a course in high-school chemistry does add to the ability of a student. If he is required to repeat all of the subject-matter previously studied, he merely studies less than his unprepared classmate. He may even cease to study and actually know less when the college course is finished than he

did when he finished chemistry in high school. If he is put in a course in which all of his classmates have taken high-school chemistry, and that class is given lessons as difficult for them as a beginner's lessons are for the beginner, he actually learns more fundamental chemistry than one who did not have high-school chemistry. When he starts analytical chemistry, organic chemistry, or physical chemistry he is not repeating the work done either in high school or in the freshman year. He is doing new work but he has a better foundation for it. The results here show that pupils ac-

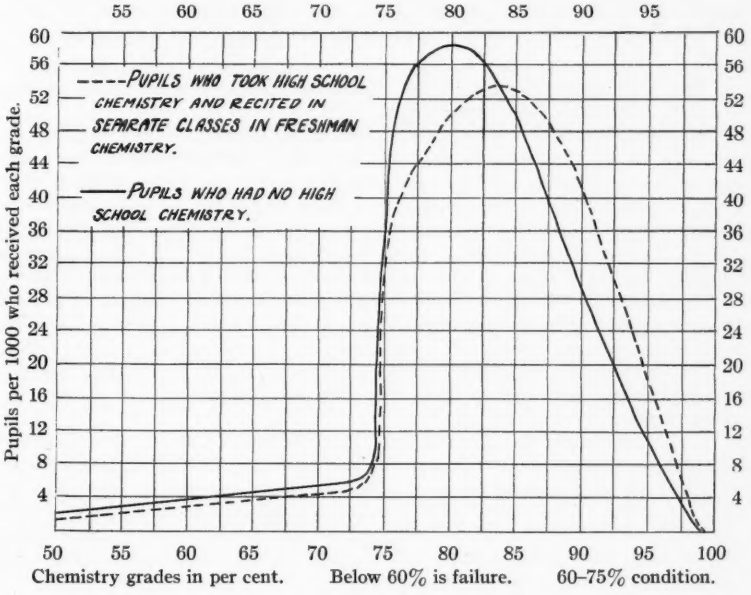
55 60 65 70 75 80 85 90 95
60 56 52 48 44 40 36 32 28 24 20 16 12 8 4
----PUPILS WHO TOOK HIGH SCHOOL CHEMISTRY AND RECITED IN SEPARATE CLASSES IN FRESHMAN CHEMISTRY.
——PUPILS WHO HAD NO HIGH SCHOOL CHEMISTRY.
Pupils per 1000 who received each grade.
50 55 60 65 70 75 80 85 90 95 100
Chemistry grades in per cent. Below 60% is failure. 60–75% condition.

FIG 1.

tually do better work because of the better fundamental training secured in this way.

The curves in Figure 1 show graphically the relations expressed in Table VI. The abscissae represent grades and the ordinates the numbers of students receiving those grades. The area under each curve represents 1000 pupils and the ordinate of any integral grade represents the number of students receiving that grade.

Any further separation of pupils on the basis of ability or training such as suggested by Hendricks,[2] or by Cornog and Stoddard,[3] would be advantageous.

[2] THIS JOURNAL, **2**, 655–8 (1925).
[3] *Ibid.*, **2**, 701–8 (1925).

Conclusions

Separate courses in chemistry should be provided for college freshmen who have taken chemistry in high school: (1) to encourage the high-school pupils and teachers; (2) to keep the freshmen so prepared from acquiring the habit of loafing; (3) because pupils so segregated do much better work in subsequent chemistry courses.

The author wishes to express his thanks to the more than thirty instructors and assistants who aided in the collection of the data presented in this paper.

French Promise Straw Houses Next. The French have a new fireproof building material. It is cheap, light, durable, soundproof, and made of straw.

The straw is pressed into rectangular panels nine feet long by six feet wide and two inches thick, bound together by lengthwise wires about six inches apart. The heavy pressure under which the panels are constructed as well as the mineral content of the straw account for its being fireproof. Solomite, as it is called, was used extensively last summer on account of its easy handling properties in the construction of many of the buildings of the Exposition of Decorative Arts at Paris. It has been found to work out very well as side walls, ceilings, and partitions, offering a convenient surface for plaster and stucco. This type of construction has proved to be very popular for summer cottages while the soundproof qualities of the material have rendered it useful in the audition rooms of music stores.—*Science Service*

Spleen an Aid in Resisting Tuberculosis and Tumors. Modern medical science is at last unraveling that physiological mystery of the ages, the purpose of the spleen in the human system.

It has been known since classical times that the spleen could be removed without any apparent ill effects on the patient. Various conjectures, all more or less erroneous as to what its purpose could be in the human anatomy, have come down to us. By the last half of the 19th century it was definitely established that it had something to do with the purification of the blood as well as the formation of some of the blood cells, and though it was not necessary for life these functions after removal were taken over by the bone marrow and other organs.

In a resumé of the more recent work done on this mysterious organ, by Dr. E. B. Krumbhaar, of Philadelphia, we find that the spleen is an important source of antibodies, those little-understood elements in the blood that help kill off bacteria. Laboratory experiments seem to show that the spleen plays a considerable part in resistance to such infections as tuberculosis and also to the growth of tumors. It has been found that tumor grafts make much less growth in the spleen than in any other organ, and that its removal definitely cuts down the resistance to tumor inoculation. Some experimenters believe that it contains a substance actually destructive to tumor cells but this has not yet been conclusively proved.

Two doctors of New York City, Dr. S. Shapiro and Dr. F. H. Frankel, have tried to ascertain the effect of feeding extracts of spleen and bone marrow upon the formation of red corpuscles. Their patients showed an increase in the number of red cells while being fed the extract but the count went down as soon as the dose was stopped. The definite establishment of the fact that such extracts contain a substance which will increase the production of red corpuscles would be of inestimable value in the treatment of many diseases, particularly anemia.—*Science Service*

ACHIEVEMENTS OF PUPILS IN LABORATORY INSTRUCTION*

HERBERT R. SMITH, LAKE VIEW HIGH SCHOOL, CHICAGO, ILLINOIS

The teaching of science in the public schools has been in operation for a hundred years, beginning with the English High School of Boston in 1824. No other branch of the curriculum has had such intimate and effective touch with the lives of people as the science subjects. The automobile has transformed the habits and lives of a large proportion of our population in the last twenty years, and there is every reason to believe that the inventions of the next two decades will surpass those of the past two, for chemistry is just beginning to touch the lives of the masses.

Chemistry, likewise the other science subjects, was not invited into the curriculum by the classics. Evidence of some stratagem being used in early days to obtain a foothold for chemistry is found in the title of an ancient text-book called "The Grammar of Chemistry." Perhaps the word grammar meant "fundamentals" for in those days grammar was much more fundamental than now. There was discipline in speech then, but now it is the day of the "speak-easy." The classics were not humanly disposed to make room on the educational bench for the somewhat odorous and as yet unrefined youngster called chemistry. There were upliftings of the nose and disdainful looks from the well-groomed Greek and Latin at the motley alchemistic garb of chemistry. But from the very first how has chemistry retaliated for all the odium heaped upon it? Has it followed the ancient Mosaic law of "an eye for an eye and a tooth for a tooth?" No. True to its desire for "whatsoever things are honest—whatsoever things are pure—whatsoever things are of good report," it has heaped coals of fire on the heads of its ancient defamers by naming each new conception and invention in the choicest sesquipedalian phrases of its sometime rivals. Metathesis, catalysis, electrolysis, deliquescence, efflorescence, decrepitation, ionization, and hypotheses of electrolytic dissociation. The glory of Greece and Rome had passed into the tomb, and their speech was fast following when chemistry resurrected it to the further service of mankind. And so will it continue to construct memorials to Greek and Latin in living phrases of modern science until the last star fades in the firmament before the eyes of the last expiring chemist.

Of all science subjects chemistry has been studied most consistently from the laboratory standpoint. There may have been schools having no laboratory work, but great must have been the forbearance of any pedagogues of the past who could resist the lure of mixing chemicals to see what would happen. Science differs in most characteristic fashion from other subjects by its laboratory practice. Not the dealings in imaginary commodities and stage currency of the business courses, nor the too often

* Read before the Chemistry Section of the Wisconsin State Teachers' Association, November, 1925.

empty phrases of the theme writer in English, nor the awkward tongue twistings of foreign language composition, nor yet the historical decipherings of an outworn age. The science laboratory opens all the avenues of approach to the brain through the senses, using the actual materials of life. *The sensations that inform are translated into knowledge by the catalysis of reason.*

However great this opportunity may be, we are compelled to say that there is laboratory practice in science and in chemistry in particular that is worse than none. We have proved it in our own laboratory. Further, we present as proof a page of a pupil's note-book from a school in an adjoining state. The pupil has prepared a saturated solution of potassium nitrate in hot water and set it aside to cool. When cool the pupil examines the result and the questions of the pupil's work book reveal his state of mind.

Is the amount of dissolved substance greater or less at the lower temperature? *Greater.*

When the liquid comes to the temperature of the room, is it a saturated or an unsaturated solution? *Supersaturated.*

How can you determine this? *By letting it cool.*

The procedure is next repeated with sodium chloride.

Which is increased the more by increase in temperature, the solubility of sodium chloride or that of potassium nitrate? *Sodium chloride.*

Make a statement concerning the relative solubility of salt in hot and in cold water. *In hot water salt dissolves more readily. In cold water not quite so readily.*

Those who know the correct answers to the above questions will agree that this pupil would be wiser playing somewhere outdoors than in the chemistry laboratory.

Dr. S. R. Powers of Teachers College has informed us of the poor results of pupils who were tested on their achievements in the study of chemistry.[1] Dr. Downing of the School of Education, University of Chicago, and his students have shown by their researches that so far as imparting information is the object, the laboratory practice as a method is wasteful in time and money.[2] We have further confirmed these results in our own laboratory. To advocate the abandonment of laboratory practice, however, would be just as sane as to abolish railroads and motor cars because some careless people are being killed every day by them. The largest diamond discovered lay on the ground valueless as any common stone until one who saw the nature of the stone gave to the world the Cullinan diamond, fit for a king. So the laboratory method, when properly shaped to bring out its values, surpasses all other methods in education. If information, only, is wanted, a book may serve the purpose better than the laboratory; but if knowledge is sought, which is information plus how to use it, plus

[1] THIS JOURNAL, **1**, 139–44 (1925); *Sch. Sci. Math.*, **25**, 53 (1925).

[2] *Sch. Rev.*, **33**, 688–97 (1925).

how to add to it in any situation, then there is nothing near the equal of the laboratory method.

One of the most serious errors of teachers is to confuse knowledge and information. Dewey says, "The method demanded by the study is the source of efficiency rather than anything inherent in its content." Barr also says, "The science that is taught should be an incident, the method the end." McPherson and Henderson, "The main object of the course in chemistry must always be to train young people to think and to imagine in the realms of chemical facts and laws." With the emphasis placed on training rather than information, and thinking rather than repeating, we will now examine some of the conditions that make or mar the success in the laboratory study of chemistry.

The equipment of the laboratory is a largely over-estimated factor. It stands large in the eyes of the public, the pupils, and frequently the teacher. The supply firms have quite persuaded us of the necessity of complete equipment, with the result that pupils are mystified as much as they are enlightened about the principle being put through its paces. They have no means of appreciating the refinements of modern apparatus because they have put no labor in the making of it. If the laboratory practice can be justified at all, then *so far as pupils can construct apparatus and obtain training commensurate with the time and effort spent*, it is fully justified. It is the most efficient type of training and presents actual life situations.

Teachers are prone to be satisfied when they have given demonstration and explanation of some principle with special apparatus, because they understand it fully from their larger experience. Then they commit the further mistake of thinking that pupils should understand it as well in one consideration as they do after many. Of all science teachers the chemistry teacher is likely to deplore the lack of apparatus and materials, yet it is possible for the teacher in a small school with meager equipment to train his pupils fully as well as any. The plan will be given in the discussion of the method.

The pupil is a factor entitled to some consideration inasmuch as the school exists for him rather than as a means of employment for the teachers or a center of propaganda for the various subjects of the curriculum. One-fourth of the pupils now completing the elementary grades enter the high school. They represent more nearly a cross section of the population than formerly, and consequently show a greater range of capabilities. The so-called grading process of the elementary schools has broken down under the modern methods of making promotions from grade to grade. It is useless to expect that the same method will be suitable for all members of a class. If anything approaching satisfactory results is to be obtained the teacher must recognize at least two fairly distinct divisions of each class on the basis of ability. Our studies at Lake View from year to year show

that about 30 per cent of the pupils enrolling for chemistry are able to follow the laboratory directions with profit for the time used. From these same studies and other data available, a conservative estimate may be made that 50 per cent of the laboratory work in secondary schools does not bring results commensurate with the time used, mainly because the conditions under which the work is done are not efficiently planned. If laboratory practice of this nature is permitted we may expect the tax-paying public, much interested in economy because of the increased taxes for educational purposes, to abolish the laboratory and relegate science teaching to the ancient lecture method, saying in modern phraseology, "You can do it better with gas."

It has been intimated that the equipment of the chemistry laboratory is not a vital factor, and we may not select the pupils for enrolment in our classes, so the point of attack on this problem of better results in teaching must be found in the methods that the teacher selects and uses. The efficient 30 per cent are active enough mentally to visualize relations from a demonstrated experiment so one might justify this method of presentation on the ground that they could cover approximately twice the subject-matter. The world's problems must be thought out by this group so they too need the practice of thinking from the facts. On the other hand it has been argued that the slow pupils need the thought work of the laboratory method most, so they should be taught by this method. But there is many a slip between the test tube and the intellect. Those who need mental training most are the very ones who do not care for it. Turning them loose in the laboratory will not train them for they are unable to stand alone mentally. They soon become enmeshed in copying and deceit and are demoralized rather than instructed. They require close supervision and must be trained in efficient methods of study before they are ready for individual laboratory work. It is wasteful of the teacher's time to teach them separately one at a time, and it is, besides, unnecessary.

At Lake View each year, in September, each class of beginning chemistry is divided provisionally into A and B groups by Terman's Group Test of Mental Ability. The A group begins laboratory practice at once, guided by printed directions. Group B is held under close observation and supervision until its members acquire confidence and capability of doing work alone. The experiment is not presented as a demonstration by the teacher. He has something of more importance to do. One or two pupils of this group are selected in rotation for each experiment or part of it as the circumstances indicate. The others are grouped about the performers, watching and writing the permanent record of the experiment. The teacher watches closely the attitude of the group, maintaining a steady fire of questions about the most essential points as they appear. The least attentive pupils are thoroughly questioned. Many points can be con-

sidered that would not come to the pupil working alone, or could not be included in the printed directions. Each essential point can be presented from different viewpoints and driven home to the pupil's comprehension by repeated questions. When the experiment is finished the teacher has the satisfaction of knowing that each pupil has thought the work through without doubt or fraud, he has the truth in mind, the record is written and *it is correct.* There is no laborious correcting of note-books. The best way to correct mistakes is to correct the thinking before the error is recorded and fixed in mind. This condition is reached with the weakest members of Group B in the same or less time than that taken by Group A to do the same work. A marked change in the attention and interest of most of the members of this group can be noticed in two weeks by the application of this plan. Much instruction is given about "how to learn." About this time all in the Group B are given some sufficiently simple experiment to perform individually, after appealing to their pride in being able to show that they also can learn by their own efforts.

From this time on Group B is led more and more into individual work until they are all merged into Group A or are eliminated at mid-year if they will not make sufficient effort to learn. It is usually possible to bring the class to a fair degree of uniformity by the end of the first semester. Extra and optional work are provided for the apter pupils so that they are never idle in laboratory practice time. If any of Group A show a serious drop in the quality of work, such persons are put in the other group for close observation until recovery is made.

It is possible for a school with meager equipment to give good training in chemistry by this plan if the supplies are sufficient for the laboratory practice of one or two persons. Necessarily the whole class under these conditions must be in one group. The more proficient pupils who obtain good comprehension on going through the experiment once, can be excused for optional laboratory or reference work while the teacher reviews and fixes the fundamentals in the minds of the less proficient pupils. One may see at this point that a poorly equipped laboratory is not a serious hindrance, the abilities of the pupils may be quite diverse and yet all can be trained and approximately leveled up in achievement. It is even possible to conduct the work satisfactorily without a laboratory manual, although we do not recommend that it be dispensed with, nor do we recommend a poorly equipped laboratory. What is insisted on is that these easily surmountable obstacles should not be used as excuses for poor teaching.

After careful testing we are quite confident that the laboratory directions that follow closely a given text-book, furnish very little training along the lines quoted above. Hence the laboratory time and materials are largely wasted. Where pupils can find the answers to questions in the manual nicely printed in the text-book that "goes with it," they will not

exercise their minds getting them from the laboratory data. Many laboratory guides ask questions that require reference work and special investigation aside from that undertaken in the experiment. Such questions distract the pupils' mind from the experimental data, which they have been using their time and the public money to obtain. When they have learned all that is possible from the experimental data, then it is highly desirable that they should consult as many books as possible for further information.

Last year at Lake View extended studies were made of the efficiency of several of the common methods of presenting chemical information. Ten experiments of the usual type difference to be found in the average manual were selected from Brownlee as subject-matter. One class in beginning chemistry was given the first experiment by the teacher-demonstration method, another by the individual method, and the third by the group of two method. Immediately after the experimental presentation each class was tested by a specially constructed choice-of-answer test furnished by Professor W. W. Carpenter of Columbia University. A fourth class was given the test *before* the experimental study to check up on previous information possessed by the pupils. The methods were rotated among the classes with each experiment so that each class might be tried in all. The Terman test was used to equate the differences of ability as found in the different classes, and at the end of eight weeks the tests were given again to test the retention of information acquired by the different methods. Detailed analysis of the data collected was made by Professor Carpenter and has been issued in printed form.[1] The more proficient pupils did better work by the individual method and the less proficient pupils by the teacher-demonstration plan. The delayed test showed that the same facts held true for retention. These results show that achievement *depends on comprehension*. The pupils who can and will work by the individual plan achieve results that are lasting and worth the time and materials used. There are further values obtained in initiative and resourcefulness. The pupils who have not learned how to direct their energies fail to achieve by the individual plan. But they do learn when held to the task of doing their own thinking by close supervision. When they have some acquaintance with the scientific method of procedure they are able to direct their energies to successful ends. The laboratory practice by twos showed little difference from the individual plan. Its chief points are the saving of time and materials. The greatest factor for success or failure is the teacher. If he has a clear conception of the objectives to be attained, and will use sufficient common sense in the selection of methods, then there are no insurmountable obstacles in the teaching of chemistry.

[1] "Certain Phases of the Administration of High-School Chemistry," W. W. Carpenter, Teachers' College *Bulletin* **191.**

FINAL EXAMINATIONS IN GENERAL CHEMISTRY*

J. H. HILDEBRAND, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

In meetings such as this we find a considerable degree of unanimity so long as we discuss generalities. We unite in asserting our belief in teaching the student to think and to have the scientific attitude of mind, rather than in cramming him with facts. But testimony in prayer-meeting does not always accord with conduct in everyday life, and Professor Cornog has called attention, as many of you will recall, to the fact that final examinations do not always bear witness to the emphasis asserted in our declarations of faith. But it is the daily life and not one's profession of faith which is truly enlightening, and I am, therefore, going to assume deliberately the risk of exposing to your criticism an actual view of the results of our teaching in the University of California, rather than to utter generalities which you might suspect to be insincere.

Indeed, I believe that courses in chemistry have too long been judged upon a very unscientific basis. The impression a text-book makes on the teacher determines its use. The best seller is often supposed to be the best text. The good teacher is not distinguished from the popular lecturer. I am not an advocate of standardized tests, but I believe the most important criterion for judging a book or a teacher to be the kind of questions the pupils can answer. Of course, I do not wish to imply that the values of a course can all be tested by the final examination; the inspiration the student may have received, and the breadth of outlook, are among the most important results of good teaching although they can scarcely be tested by examination.

The purposes and methods of the course we give in the University of California have been set forth in the introduction to the "Course in General Chemistry," by Bray and Latimer; also by myself in *Science*, **55,** 355 (1922). Any repetition here is, therefore, uncalled for. In making the final examination questions for this course we have borne in mind the fact that great progress has been made in recent years in the technic of giving examinations which can be graded with a minimum of labor and without the uncertainties and inequalities in marking inevitable when the older type of examination is graded by a number of readers. The students like this type of examination both because the questions are exceedingly definite, and because many questions can be asked, so that accidental slips have but a minor effect upon the grade. Several samples of recent papers are presented herewith. The first is the final examination in the course in May, 1925. Following the custom adopted during the term this was an open book examination. We are coming to the conclusion that this plan more closely approximates the actual conditions of life, and that it removes

* Presented before the Division of Chemical Education at Los Angeles, August, 1925.

emphasis from mere memory work. It will be noted that reference books would furnish but minor assistance in answering these questions. The average grade of the class in this examination was 67 per cent, and 18 per cent of the class secured grades of 80 and above.

UNIVERSITY OF CALIFORNIA (Course Examinations)

CHEMISTRY 1B, GENERAL CHEMISTRY, SECTIONS I AND II

Instructor in Charge, Professor HILDEBRAND

Answer all questions on this sheet in the manner indicated. Do not use "blue books." Ordinary reference books and the course note-books may be consulted as desired.

Name of Student .....

Name of Laboratory Instructor .....

1. Supply appropriate words in the spaces below. Do not guess, as a wrong word counts −2.

From the place of lanthanum in the Periodic System of elements its principal oxide should have the formula....., and its chloride the formula..... Its hydroxide should be.....soluble in water than $Ba(OH)_2$ and..... .....soluble in NaOH than aluminum hydroxide. The free element should be a .....conductor of electricity and should have a .....melting point than barium. Its ion should have ..... tendency to form complex ions.

(Credit 14)

2. Supply the equation and the missing words in the following statement. Do not guess, for −2 will be assigned for each wrong answer.

An electric battery is made by using a cadmium amalgam for one electrode, another electrode of Cl_2 at 1 atmosphere surrounding a graphite rod, and between them a solution of $CdCl_2$. The equation for the reaction is..... In this reaction the Cl_2 is the ..... agent. The electromotive force of the cell would be increased by ..... the concentration of $CdCl_2$, by ..... the concentration of Cd in the amalgam, by ..... the pressure of Cl_2, or by ..... the temperature, keeping the pressure of Cl_2 at 1 atmosphere. (Heat is evolved while the cell discharges.)

(Credit 16)

3. (*a*) How many grams of iodine will be produced if 2 mols of NaI and 3 mols of $FeCl_3$ are mixed in dilute acid solution? Ans. .....

(*b*) *500 cc. of 0.2 M-*$Cu(NO_3)_2$ *is mixed with 500 cc. of 0.2 M-*$Pb(NO_3)_2$ and 27 g. of metallic aluminum is added. After the reaction is complete what ions will be present in the solution, and what will be the concentration of each? Ans. .....

(*c*) How many mols of K_2CrO_4 will be required to yield 5 liters of Cl_2, measured at standard conditions, by reaction with conc. HCl? Ans. .....

(Credit 10)

4. Write the formulas of the following substances in the spaces provided:

(1) A constituent of gasoline .....
(2) An organic analogue of NaOH .....
(3) An organic analogue of Na_2O .....
(4) An organic acid containing 6 carbon atoms .....
(5) An anaesthetic .....
(6) An abrasive .....
(7) An insecticide .....
(8) A parent substance in dye manufacture .....
(9) The poisonous constituent of illuminating gas.....

Give the formulas of reagents that will

(10) Dissolve CuS but not HgS .....
(11) Dissolve $BaCrO_4$ but not $BaSO_4$ .....
(12) Dissolve SnS_2 but not SnS .....
(13) Dissolve PbO_2 .....
(14) Dissolve HgCl but not AgCl .....
(15) Reduce Hg^{++} but not Hg^{+} .....
(16) Change Sn to H_2SnO_3 .....
(17) Change $BaCO_3$ to $BaSO_4$ but not $CaCO_3$ to $CaSO_4$ .....
(18) Dissolve $PbSO_4$ but not PbS .....
(19) Dissolve Ag but not Au .....
(20) Give a delicate test for a fairly strong oxidizing agent .....

(Credit 20)

5. A solid unknown was made by selecting certain of the following salts: $CaSO_4$, $AgNO_3$, $PbCl_2$, $FeSO_4$, $(NH_4)_2SO_4$, $CuSO_4$, $Ba(NO_3)_2$, Na_2CrO_4, $Cr_2(SO_4)_3$, Na_2CO_3.
Upon treating the unknown with hot water a white solid is left which, after filtration from the solution, is found to be soluble in 6 N-NaOH but insoluble in 3 N-HNO_3 and insoluble in NH_4OH. The filtrate gives a red color with litmus, yellow with methyl orange, and upon the addition of 6 N-NaOH gives a colorless solution with an odor of ammonia, and containing a suspended greenish precipitate.
On the basis of these observations, underline all constituents in the above list that are known to be present, cross out all that are known to be absent, and leave unmarked all whose presence is doubtful. (Credit 20)

6. An unknown solution is being tested for the presence of the following ions or complex ions, etc., derived from them: Ag^+, Al^{+++}, Ba^{++}, Cr^{+++}, Cu^{++}, Fe^{+++}, Fe^{++}, Hg^{++}, Hg^+, K^+, NH_4^+, Pb^{++}, Zn^{++}, CO_3^{--}, CrO_4^{--}, Cl^-, H^+, OH^-, NO_3^-, SO_4^{--}.
All ions not listed may be assumed to be absent.
Distinct observations are made upon separate portions of the original solution as follows:
(*a*) The addition of Na_2CO_3 solution causes effervescence at first, and added in excess gives a precipitate.
(*b*) Addition of $BaCl_2$ solution gives no precipitate.
(*c*) N-H_2SO_4 gives no precipitate.
(*d*) 6 N-NaOH in excess gives a colored precipitate, the filtrate from which is colorless and smells of NH_3.
(*e*) H_2S gives a nearly white precipitate and the filtrate has a color different from that of the original solution.
On the basis of these observations considered as a whole, underline the formulas of all constituents in the above list which are known to be present in appreciable concentration, cross out all known to be absent, and leave without mark all whose presence is doubtful.
(Credit 20)

April–May, 1925.

The examination given to the same class at the end of the first term, Dec., 1924, was a closed book examination, here reproduced. The average grade was 63 per cent, and 12 per cent of the class received 80 and above.

UNIVERSITY OF CALIFORNIA (Course Examination)

CHEMISTRY 1A, GENERAL CHEMISTRY, SECTIONS I AND II

Instructor in Charge, Professor HILDEBRAND

Answer all questions on this sheet in the manner indicated. Do not use "blue books."

Name of Student .....
Name of Laboratory Instructor .....

1. Write the formulas of the following substances in the spaces provided:
(*a*) Two ammonia complex ions ..... (1) .....
(2) .....
(*b*) A deliquescent salt .....
(*c*) A volatile salt .....
(*d*) The nitrate of a divalent element .....
(*e*) Boric oxide .....
(*f*) A salt that would color the bunsen flame red .....
(*g*) Cuprous sulfide .....
(*h*) A salt giving an acid reaction when dissolved in water .....
(*i*) A salt giving an alkaline reaction when dissolved in water .....
(*j*) The chief constituent of ruby .....
(*k*) A metal which is nobler than zinc but baser than silver .....
(*l*) The two substances mixed to make magnesia cement ..... (1) .....
(2) .....
(Credit 14)

2. An unknown solution is being tested for the presence of the following ions, or combinations of them: H^+, OH^-, Na^+, K^+, Ca^{++}, Cu^{++}, Zn^{++}, Ag^+, NH_4^+, SO_4^{--}, Cl^-, NO_3^-, CO_3^{--}.
All ions not listed may be assumed to be absent. It is found by experiment that the addition of $BaCl_2$ solution to the unknown solution gives a white precipitate which dissolves completely upon addition of HNO_3. On the basis of this observation, underline all constituents in the above list that are known to be present, cross out all that are known to be absent, and leave unmarked all whose presence is doubtful. (Credit 13)

3. Another unknown solution may contain the following constituents but no others: H^+, OH^-, K^+, Ca^{++}, Na^+, Cu^{++}, Zn^{++}, Ag^+, NH_4^+, SO_4^{--}, NO_3^-, CO_3^{--}, Cl^-.
The solution gives a red color to phenolphthalein, and does not smell of ammonia. Indicate the presence or absence of the various constituents in the manner used in question 2.
(Credit 13)

4. Answer the following questions by underlining the proper substance in each list given.
(*a*) Which solution has the highest concentration of OH^-?
0.1 M-NaOH; 1 M-NH_4OH; 0.1 M-$Ba(OH)_2$; 1 M-NaAc.
(*b*) Which solution has the lowest concentration of OH^-?
0.1 M-NaOH; 0.01 M-$Ba(OH)_2$; 1 N-NaAc; 0.01 M-KNO_3.
(*c*) Which solution has the lowest concentration of H^+?
0.001 M-HNO_3; 0.05 M-HAc; 1 M-NH_4Cl; 0.01 M-HCl.
(*d*) Which solution has the highest concentration of H^+?
0.1 M-H_2CO_3; 0.05 M-HAc; 1 M-NH_4Cl; 0.01 M-HCl.
(*e*) Which is the least soluble? $Ca(OH)_2$; $Ba(OH)_2$; $Zn(OH)_2$.
(*f*) Which is the least soluble? AgCl, $BaCl_2$, $ZnCl_2$, KCl, NaCl.
(*g*) Which gives off CO_2 at the lowest temperature?
$CaCO_3$; Na_2CO_3; Ag_2CO_3; $ZnCO_3$; $CuCO_3$.
(*h*) Which is the most volatile? KCl; NH_4Cl; KOH; NH_4OH.
(Credit 24)

5. In answering the following questions it is not necessary to show your work, the answer alone will be graded.
Atomic weights needed: H = 1; O = 16; S = 32; Al = 27; Na = 23.
(*a*) How many gram-atoms of oxygen are combined with 3 gram-atoms of aluminum in the compound Al_2O_3? Ans. .....
(*b*) How many grams of aluminum are necessary to make 3 grams of Al_2O_3?
Ans.....
(*c*) What volume of SO_2, measured at standard conditions, could be produced from 8.0 grams of sulfur? Ans.....
(*d*) How many cc. of 0.1 M-H_2SO_4 must be taken to contain 1.96 grams of H_2SO_4?
Ans.....
(*e*) Give the concentration of OH^- in mols per liter, as nearly as you can, in each of the following solutions:
(1) 4.6 grams of sodium is dissolved in 500 cc. of water Ans.....
(2) 0.1 mol of CaO is dissolved in 2 liters of water Ans.....
(3) 1 M-NH_4OH Ans.....
(4) 0.1 M-NaCl Ans.....
(5) 1 M-NaAc Ans.....
(6) 0.1 mol of NaOH and 0.2 mol of $Ba(OH)_2$ are dissolved in 5 liters of water
Ans.....
(7) 0.2 mol of HCl in 500 cc. of solution is mixed with 0.2 mol of $Ba(OH)_2$ in 1500 cc. of solution Ans.....
(*f*) Some air was passed through an ozonizer which changed part of the oxygen to ozone, O_3. If the air diminished 2% in volume what per cent of the oxygen was changed to ozone?
Ans.....
(Credit 36, 3 for each problem.)

I will give but one further example, namely, the final examination (closed book) given in May, 1924. In this examination the class average was 68, and 21 per cent of the class were above 80.

CHEMISTRY 1B, GENERAL CHEMISTRY, SECTIONS I AND II
Instructor in charge, Professor HILDEBRAND
Answer all questions on this sheet in the manner indicated. Do not use "blue books."

Name of Student .....
Name of Laboratory Instructor .....

1. Write the formulas of the following substances in the spaces immediately following their names.

(1)	Potassium perchlorate	(7)	A reagent that will dissolve SiO_2 .....
(2)	A yellow pigment	(8)	A reducing agent for use in alkaline solution .....
(3)	Silver cyanide complex ion		
(4)	Hypochlorite ion	(9)	A reducing agent for use in acid solution .....
(5)	Magnetic iron ore		
(6)	Aluminum phosphate	(10)	Hexane.....

(11) Ethyl alcohol ..... (16) Ethyl acetate .....
(12) Benzene ..... (17) A weak soluble salt .....
(13) Acetone ..... (18) Ammonium nitrite .....
(14) Formaldehyde ..... (19) Stannous acid .....
(15) Dimethyl ether ..... (20) Ammonium dichromate .....

(Credit 20)

2. State briefly in the space allowed the basis underlying the difference in behavior in each of the following cases:
   (1) Al^{+++} is hydrolysed but K^+ is not: .....
   (2) $MgCO_3$ decomposes readily upon heating but Na_2CO_3 does not: .....
   (3) $BaCO_3$ is soluble in HCl but $BaSO_4$ is not: .....
   (4) $PbSO_4$ is soluble in NaOH but $BaSO_4$ is not: .....
   (5) Ag_2CO_3 is soluble in NH_4OH but $CaCO_3$ is not: .....
   (6) SnS_2 is soluble in $(NH_4)_2S$ but SnS is not: .....
   (7) ZnS is soluble in 0.3N-H^+ but CuS is not: .....
   (8) Cu is soluble in HNO_3, but not in HCl: .....
   (9) PbO_2 is soluble in HCl but not in HNO_3: .....
   (10) Au is soluble in HNO_3 + HCl but not in HNO_3 alone: .....
   (11) FeI_3 decomposes in solution but $FeCl_3$ does not: .....
   (12) CuCl is stable but $CuNO_3$ decomposes into $Cu(NO_3)_2$ + Cu: .....
   (13) A solution of $NaSbO_3$ is more alkaline than one of $NaAsO_3$: .....
   (14) The equilibrium $CO + {}^1/_2O_2 = CO_2$ is shifted to the right by increasing pressure, but the equilibrium $N_2 + O_2 = 2NO$ is not altered: .....
   (15) The equilibrium $BaSO_4 + CO_3^{--} = BaCO_3 + SO_4^{--}$ is altered by adding more CO_3^{--} but not by adding more $BaSO_4$ .....

(Credit 30)

3. Write the formulas (ionic where necessary) of all new substances formed, other than H^+, OH^-, or H_2O, after reaction in each of the following cases:
   (1) H_2S is passed into a solution of H_2SO_3 .....
   (2) H_2S is passed into an acid solution of $Fe_2(SO_4)_3$ .....
   (3) A precipitate of $Fe(OH)_2$ is treated with a solution containing ClO^- .....
   (4) HgS is treated with Br_2 solution: .....
   (5) Iron is put into a solution of $FeCl_3$: .....
   (6) A solution of $CrCl_3$ is treated with an excess of Na_2O_2: .....
   (7) Cl_2 is passed into $Fe(CN)_6^{----}$ solution: .....
   (8) P_4S_3 is burned in dry air: .....
   (9) MnO_2 is heated with HBr solution: .....
   (10) 0.1 mol of Zn is put into a solution containing 1 mol of $HgCl_2$ and 0.5 mol of $Cu(NO_3)_2$: .....

(Credit 20)

4. An unknown solution is being tested for the presence of the following ions or complex ions, etc., derived from them: Al^{+++}, Ba^{++}, Cr^{+++}, Cu^{++}, Fe^{+++}, Fe^{++}, Pb^{++}, Hg^+, Hg^{++}, Na^+, NH_4^+, K^+, Ag^+, Zn^{++}, SO_4^{--}, NO_3^-, CO_3^{--}, H^+, OH^-, Cl^-.
   All ions not listed may be assumed to be absent.
   Three distinct experiments are made upon separate portions of the original solution as follows:
   (*a*) Dilute HCl has no visible effect,
   (*b*) NaOH solution in excess gives a deep blue solution containing no suspended precipitate,
   (*c*) $BaCl_2$ solution gives a white precipitate.

On the basis of these observations considered as a whole, underline the formulas of all constituents in the above list which are known to be present, cross out all known to be absent, and leave without mark all whose presence is doubtful.

(Credit 20)

5. (1) How many mols of Fe^{++} can be oxidized by 1 mol of MnO_4^- (which gives Mn^{++} in acid solution)? Ans.....

(2) What is the per cent of iron in an ore, 0.224 g. of which, dissolved in acid and the iron reduced to ferrous, requires for its titration 40.0 cc. of 0.05 M-$KMnO_4$ solution? (Atomic weight of Fe = 56) Ans.....

(Credit 10)

May, 1924.

I would like to refer, in closing, to a recent criticism that the University of California does not recognize high-school chemistry. This is a somewhat false deduction from the fact that we do not give a separate course for students who have not had high-school chemistry. We require for admission to the course high-school chemistry, with a grade of 1 or 2; however, there are some students who have had no chemistry, but whose training in physics and mathematics has laid sufficient foundation for success in chemistry, hence, although they are at somewhat of a disadvantage, students are admitted without chemistry provided they have had high-school physics and mathematics, including trigonometry. A student with a high-school grade of 3 in chemistry is not admitted unless he has had either physics or trigonometry. This procedure has been partly responsible for stimulating the study of chemistry in the high schools of California, so that now a large majority of students entering the University have had chemistry in the high school. It is fairer to say, therefore, that we recognize high-school chemistry so fully that we refuse to duplicate it in the University.

We feel that students who pass examinations such as the above have learned a considerable amount of chemistry and have shown that they are able to do constructive thinking with chemical material. Some of the questions could have been improved, and I leave it to colleagues in other institutions to make such use of these methods as may seem to them appropriate.

Argon Found in Living Cells. Electric light bulbs are not the only things that contain argon. This supposedly rare inert gaseous element has lately been discovered in the cells of a number of organisms, and is presumably present in the cells of all living things. A French scientist, A. Pictet, reported recently before the Paris Academy of Sciences that he and two associates had extracted a little less than a third of a cubic centimeter of the gas from a gram of dried yeast, and that they had later found it also in sheeps' brains and in the blood of oxen. They explain its presence on the hypothesis that the gas, being exceedingly inactive chemically, slowly accumulates in the cells as it is carried there, and has no means of elimination because it does not combine with other elements. It thus remains stored in the cells until their death and disintegration.
—*Science Service*

A DEVICE FOR CONSTRUCTING MODELS OF CARBON COMPOUNDS

W. H. DORE, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIFORNIA

In teaching organic chemistry some form of solid model to demonstrate the space relationships of the atoms in the molecule is indispensable. Such models, however, are not used as frequently as is desirable because of the expense and trouble that are involved in their construction. To help overcome that difficulty, the author offers this description of a convenient and inexpensive method for preparing stereo-chemical models. The materials are readily obtainable and the construction work can be done by students or by anyone who is handy with tools.

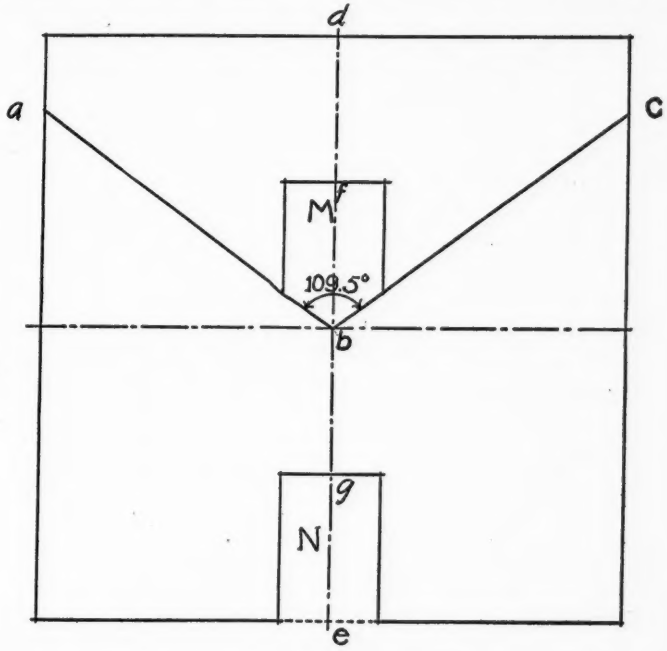

FIG. 1.

The conventional system of balls and wires is used. Plain wooden balls of about 30 mm. diameter are obtainable from novelty stores or mills for about one dollar per hundred. Holes are bored in these and the balls are joined by stiff steel wire (No. 18, B. & S. wire gauge = 0.04″).

Probably the most perplexing detail in the construction of these models is boring the holes in the balls representing the carbon atoms at the proper

angles to give the tetrahedral structure. This difficulty may be readily overcome by following the directions which are given below.

Obtain a piece of board about six inches square and saw it, as shown in Fig. 1, on the lines *ab* and *cb*. The angle *abc* should be exactly 109.5° and should be bisected by the line *db* which is perpendicular to the top line of the drawing. The board is thus cut into two pieces so that $db = be$.

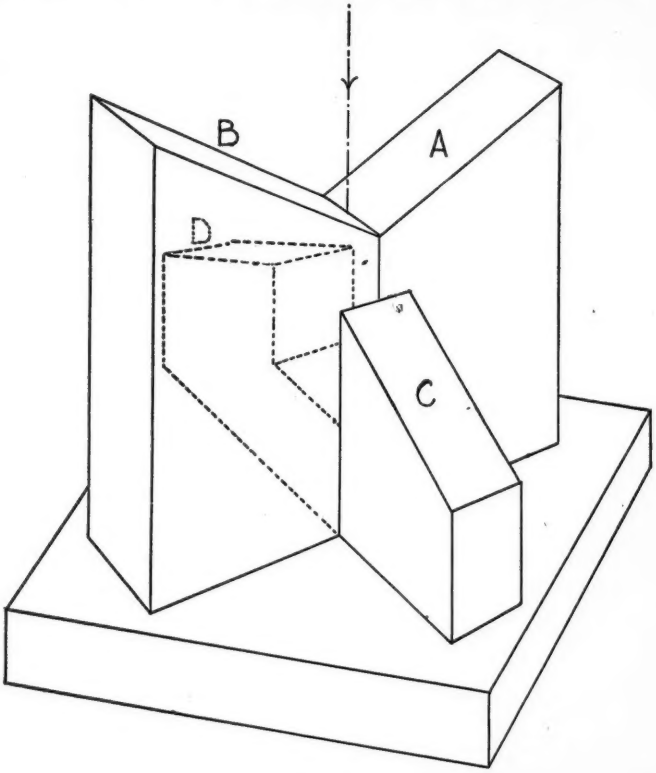

FIG. 2.

Next cut out the notches *M* and *N* so that *df* and *ge* are equal and the notches are equal in width to the thickness of the board.

Assemble the boards by dove-tailing the notches together as shown in Fig. 2. Nail or screw the pieces to a baseboard to secure stability. Then bore a vertical hole at the intersection of the pieces, using a bit having a diameter slightly larger than that of the balls which are to be used. The hole should be bored about one inch deep; care should be

taken not to get too near the junction of the two notches and so weaken the dove-tail. The dotted line and arrow in Fig. 2 show where the hole is to be bored; the larger circle in Fig. 3 shows how it appears from above while Fig. 4 shows it in cross-section.

The four edges, *A*, *B*, *C*, and *D*, of the intersecting pieces will take the direction of the tetrahedral bonds. If a ball be placed in the cylindrical bore and be supported at just the right height, the surfaces, *A*, *B*, *C*, and *D*, will serve as guides for boring the holes and placing the wires. In order to adjust correctly the position of the ball in the cylindrical bore, screw a large headed wood screw in the center of the hole as shown in the cross-section (Fig. 4). This screw should be so set that the center of the ball

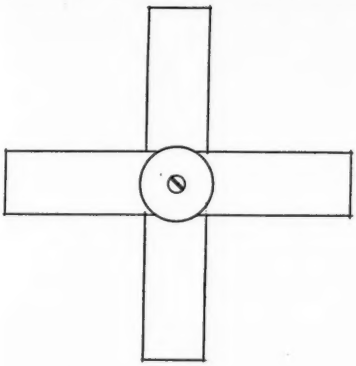

FIG. 3.

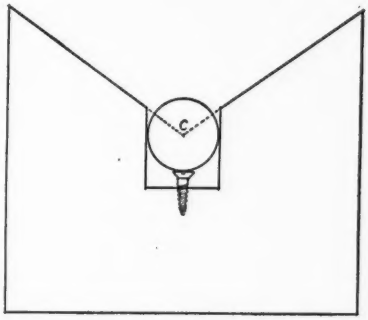

FIG. 4.

comes at the imaginary intersection point of the projected planes, *A*, *B*, *C*, and *D*.

Four small nails should be placed on each of the planes, *A* and *B*, as shown in Fig. 5, their purpose being to guide the boring tool and wires. It has been found convenient to first mark each hole rather deeply with an ice pick, held on *A* as shown in Fig. 5, then remove the ball and bore it with a drill bit which is held in the chuck of a lathe while the ball is pressed against it.

One hole is bored as described and a short wire is inserted in the hole. The ball is then placed in the pocket again with the wire extending along plane *B* and between the nails. With its location and direction thus fixed, another hole is marked by the pointer, resting it on plane *A*. After boring the hole a wire is inserted in this hole also. The ball is again placed in the pocket, this time with the wires lying along the central lines of planes *C* and *D*. The remaining holes are then marked by the pointer resting it on planes *A* and *B*.

The balls representing oxygen, as well as carbon atoms, should be

bored in this manner in order to conform to the modern conception of tetrahedrally placed valences for oxygen. Only two wires, however, are used to represent the primary valences. If desired, the other two points may be marked and brass headed tacks driven in to indicate the probable location of residual valences. Hydrogen has, of course, only

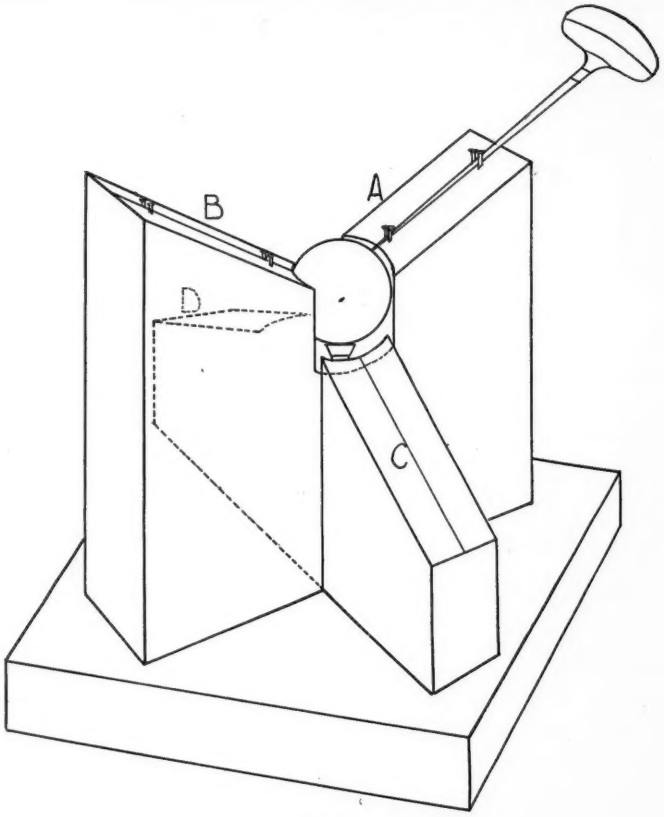

FIG. 5.

one primary and no secondary valence, consequently it is represented by a single wire.

It has been found useful to have the wires of such length as to keep the distance between the balls proportional to their atomic radii. (For a table of atomic radii in Ångstrom units, see *Science*, **61**, 544, May 29, 1925.) A convenient-sized model is obtained if the balls are spaced so that their centers are separated by as many millimeters as there are hun-

dredths of an Ångstrom unit in the average of their atomic radii. For example, in uniting carbon and oxygen, whose radii are 0.73 Å. U. and 0.65 Å. U., respectively, the average, 0.69 Å. U., would establish the spacing between centers as 69 mm. By adhering to this scale, it becomes possible to compare X-ray spectrum data with measurements upon the model.

To avoid confusion of the different atoms, the balls should be painted, each element having a characteristic color. The author has used black for carbon, red for oxygen, and white for hydrogen. If these are varnished after painting, the model is given an attractive appearance and photographs well. For photographic purposes, however, the red balls reproduce much like the black ones. By painting white bands or white spots on the red balls, they become readily distinguishable in the photographs.

Body May Put Up with Defective Diet. Evidence that the bodies of men and animals are not quite so exacting in their protein food demands as biochemists had supposed is obtained from important experiments in nutrition performed at the University of Illinois, by Drs. William C. Rose and Gerald J. Cox.

The experiments resulted in successful use of an artificial product to replace histidine, which was previously thought to be one of the 20 building stones of protein essential for the growth and development of men and animals.

The fundamental raw materials for the survival, growth and reproduction of animals have been grouped under four heads; sufficient fat or sugars to supply energy for body heat and locomotion; a small amount of metallic salts; accessory substances, known as the vitamins; and nitrogenous materials containing some of each of the 20-odd "amino-acids" of which the proteins are constructed.

Hitherto, animals fed on artifical diets lacking one or more of the amino-acids, failed to develop properly. Dr. Rose demonstrated, however, that experimental laboratory animals reached maturity if, instead of histidine, a substance similar but lacking the characteristic amino group, was eaten.

"This is the first time that a synthetic product, devoid of an amino group, successfully replaced histidine," Dr. Rose explained. "Growth, while not so rapid, was decided."

Presumably, the successful substitute, imidazole lactic acid, stole an amino group from other amino acids in the artificial diets.

The discovery may be of two-fold practical significance, it is pointed out. Proteins classed as "incomplete," such as gelatin which lacks three of the essential amino acids, may be rendered adequate from the nutritional point of view by the addition of relatively simple compounds. Again, future economic or agricultural conditions may render it expedient to manufacture food proteins, instead of waiting for the process to be carried on naturally by plants. In such an event, the synthetic chemists now know that substances approximating, but not duplicating the natural materials, may be adequate for maintaining the health and functioning of the body.

The report is of particular interest in view of the fact that histidine is a constituent of nearly all common proteins and as such has been regarded as fundamental.—*Science Service*

COLLOIDS IN INDUSTRY*

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The colloidal state of matter in the past has been largely developed on the assumption that the ultimate unit in colloidal solutions is not the isolated molecule or ion, but an aggregate of molecules or ions, or the so-called *micella* or crumb-like particle. It seemed improbable, however, that such aggregates would combine in strictly chemical proportions with acids, alkalies, or salts. The conclusion was therefore drawn that the electrolytes were adsorbed on the surface of the colloidal particles, according to a purely empirical formula, commonly known as Freundlich's[1] adsorption formula.

It is apparent, therefore, that no general theory of colloids to apply in all cases can be given. As the study of colloids has become an extensive science the development will be slow, and only when a great amount of data has been supplied by extensive physico-chemical research, properly systematized, will the theory of colloidal solutions be raised to the standing of an exact science.

When we turn, for example, to liquids we know much more about them than we do about solids. For example, we know the molecular weights of substances in the liquid state. The study of the physical properties of liquids has been very thoroughly dealt with; but even here what we know is comparatively little in proportion to what we do not know. On the other hand, the laws of gases are comparatively simple and well understood, for the reason that matter in the gaseous state lends itself to mathematical treatment in a way that no other state of aggregation does.

In recent years, however, it has become possible to deal with solutions by truly scientific, *i. e.*, mathematical, methods. This is due to no small degree to the relations, pointed out by van't Hoff, between solutions and gases, and since solution lies right at the foundation of all chemistry there is no doubt but that great progress has been made by the conversion of this branch of chemistry into an exact science.

According to the late Dr. Loeb[2] of the Rockefeller Institute, it was an unfortunate historical accident that the colloidal behavior of proteins and other similar substances was investigated before convenient methods of measuring hydrogen-ion concentration existed. If these had been applied in former years it is possible we would never have heard of the idea that the chemistry of colloids differs greatly from the chemistry of crystalloids. In other words, it was this methodical error of not measuring the

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[1] "Kapillarchemie," Akademische Verlagsgesellschaft, Leipzig, **1909**, p. 50.

[2] "Proteins and the Theory of Colloidal Behavior," McGraw-Hill Book Co., New York, **1924**, p. 5.

hydrogen-ion concentrations of colloidal solutions and gels which has retarded the development of an exact theory for colloidal behavior.

Although no new concepts of a fundamental nature were presented at the last Colloid Symposium the program showed that practically every phase of theoretical and applied colloid chemistry was touched upon. This included soils, catalysts, paint pigments, soaps, emulsions, orientation of molecules, electrokinetic potentials, photographic sensitizing substances, aluminum flocs in water purification, plasticity of rubber, as well as the study of the Brownian movement. While these are more or less recent developments they are not new to those who have been following the colloidal field during recent years.

The colloidal state is usually defined as that state of matter in which the ultimate units in solution are no longer isolated molecules or ions, but aggregates of molecules, for which Naegeli introduced the term micella, or small crumb. The essential characteristics of the constituents of colloidal solutions are therefore very small ultramicroscopic particles, of which the dimensions lie between the molecular and microscopic sizes. These particles (ultra-microns) have the same relations in colloidal solutions as the isolated molecules have for the crystalloidal solutions.[3]

Colloidal Suspensions and Crystalloidal Solutions

Thomas Graham,[4] who is usually considered the father of so-called colloidal chemistry, suggested the distinction between colloidal and crystalloidal substances, but it was later found that the same substance, for example, NaCl, may behave when in solution as a colloid or crystalloid. Paal[5] found that sodium chloride gave a so-called colloidal solution in benzol, while, of course, it gives a crystalloidal solution in water. More recently von Weimarn has demonstrated by preparation of so-called colloidal solutions of over two hundred chemical substances, including salts, elements, etc., that by proper manipulation almost any substance which exists in solid state can be produced in solution, either as a colloid or crystalloid, and in a large number of cases it is merely a question of the concentration of the reacting components; whether the crystalloidal or colloidal state results. Modern work has therefore shown that it is incorrect to speak of colloidal substances as a particular class. For instance, the alkali salts of the fatty acids (stearic, palmitic, oleic, etc.) dissolve in alcohol as crystalloids with more or less normal molecular weights, but when dissolved in water take on more of the colloidal behavior. It is, therefore, better to distinguish between the colloidal and crystalloidal states of matter than to speak of colloids and crystalloids.

[3] Zsigmondy, "Kolloidchemie," Otto Spamer, Leipzic, **1920**, p. 8.
[4] Graham, *Phil. Trans.*, **151**, 183–224 (1861).
[5] *Ber. deutsch. Chem. Ges.*, **39**, 1436, 2859 (1906); **41**, 51 (1608); **42**, 277 (1909).

It is generally conceded that in the colloidal state the particles carry an electrical charge, or, in other words, that there is a potential difference between the liquid and the micellae dispersed therein. To determine the nature of a charge on a colloid we may compare the various concentrations of electrolytes required to produce turbidity or approach the iso-electric point. For instance, factory wastes in streams are frequently precipitated by the use of alum. This can be effected because a large number of suspensions of solids in water carry a negative charge. The Al^{+++} in alum with its positive charge of three, neutralizes the negative charge, causing precipitation. On the other hand, the sulfate ions in alum are adsorbed by most colloids. This tends to peptize or help dissociate negatively charged aggregates.

Membrane Equilibrium and Peptization

By "peptization" is meant the diminution of the size of aggregates, and peptization is, therefore, the reverse of flocculation or coalescence of aggregates. The mechanism of the diminution of size of aggregates is not always the same. In the case of the action of pepsin on boiled white of egg, we are dealing with a process of hydrolysis resulting in the transformation of the insoluble compound into products possessing true solubility. In other cases the influence on solubility may be due to ionization. Thus when the solubility limit of gelatin at the iso-electric point is exceeded and an opaque suspension exists, the solution may clear up when the solubility is increased by the addition of a salt, especially with an ion of higher valency.

The precipitation of colloids by electrolytes is usually an irreversible phenomenon. The colloid particles clot and form a precipitate which will not go back into the colloidal state. There are, however, exceptions to this general rule. It has been found that when gold from a gold sol is deposited by cataphoresis, it readily passes back again into the water, reproducing the original, homogeneous sol.

Glue, gelatin, soap, gums, etc., are not readily soluble in water. In fact, they are in reality peptized by water, that is to say, subdivided into particles larger than molecules.

Instability of Colloids

Frequently the dispersed solid does not remain in the colloidal or suspended condition. We have seen that these particles while in suspension are, as a rule, electrically charged and that all the particles in a given suspension have the same kind of charge. For example, in some suspensoids the particles all carry a positive charge, while in others they carry a negative charge. In either event the particles in any given suspensoid all have the same charge and naturally repel each other. This, of course,

tends to keep the particles apart, preventing the formation of a clot or precipitate, thus tending towards stability. Acting counter to this, however, is the surface tension between the solid particles and the liquid. The action of surface tension is always to draw the object into the smallest possible volume for a given mass. A good example of this is the action of mercury which, when thrown upon a table, forms little spherical particles. In the case of colloids this tends to draw the small colloidal particles together forming larger particles, which are the units of clots or precipitates.

We have then these two forces acting counter to one another, and we can readily understand the action of electrolytes in causing precipitation. When so-called colloidal solutions are exposed to the air, precipitation often takes place, probably due to the fact that the air contains a large number of electrolytes, which are adsorbed. An example of this is the action of carbon dioxide upon emulsions. You will find if you expose a fairly stable emulsion to air which has present considerable quantities of carbon dioxide that the surface of the emulsion will be affected. This is especially so in the cases of higher temperatures; it is not so noticeable at temperatures below 15°C.

The Helmholtz[6] theory of cataphoretic migration assumes that the sign of migration is determined by a film of water, which adheres to and moves with the solid particles; that this film is usually negative in its charge due to an excess of negative ions which are forced into the film through forces present in the water (presumably surface tension). If the two ions of an electrolyte lower the surface tension of water to a different extent, that ion which has the greater depressing effect on the surface energy tends to concentrate in the outer layer, that is, the stratum, which adheres to and moves with the particle. It may be that the molecules of water are oriented by such forces at the surface of the water, in which event the hydroxyl ion forms the outermost and the hydrogen ion the deeper stratum of the surface.[7] Therefore negative ions are forced in excess into the outermost stratum at the surface of the water, the positive ions being in excess in the stratum beneath. The forces which keep crystalloids in solution, according to Langmuir[8] and Harkins[9] are those of secondary valency—of attraction between the molecules of the solute, or groups of that molecule, and the molecules of water. According to this theory acetic acid is soluble in water because the COOH group possesses an affinity for water on account of the strong secondary valency. Oleic acid is not so soluble because the affinity of the hydrocarbon chains for

[6] *Wied. Ann.*, **7**, 337 (1879).
[7] H. A. McTaggert, *Phil. Mag.*, **27**, 297 (1914); **28**, 367 (1914).
[8] *J. A. C. S.*, **39**, 1848 (1917); *Chem. Met. Eng.*, **15**, 468 (1916).
[9] "Colloid Symposium Monograph," Vol. II, pp. 141–73 (1925).

water is less than their affinity for each other. For this reason when oleic acid is placed on water the acid spreads upon the surface, because by so doing the COOH group can dissolve in the water without separating the hydrocarbon chains from each other.

If the surface on which the acid spreads is sufficiently large the double bond in the hydrocarbon chain is drawn onto the water surface, so that the area occupied is much greater than in the case of a saturated fatty acid. In this way it is explained that oils which do not contain active groups, such as paraffin oil, do not spread upon the surface of water.

Conclusion of Introduction

Before concluding this brief survey of the colloid field it might be called to your attention that there have been many objections raised against the all-inclusiveness of the term "colloid." To take its place there have been suggested such other terms as "capillary chemistry," "micro-chemistry," "chemistry of dispersoids," "chemistry of the realm of neglected dimensions." Prof. P. D. Zacharias of Athens has recently proposed in the "Kolloid-Zeitschrift," Part 1, **1925**, the term "meta-chemistry" and under this title are to be considered all of the problems which are now classed under the various groups described above, just as the term "meta-physics" in the past covered all uninvestigated processes. Thus workers would not be handicapped by the various hypothetical suppositions and prejudice created through the misunderstanding of the term, colloid.

It is, therefore, at this point proper to emphasize that it would perhaps be far better to refer to all so-called colloid mills as disintegrating mills or homogenizers, since they tend to make the product more homogeneous or uniform throughout. The term "colloid mill" does not seem to express this type of machine. Machines of this type will, therefore, be referred to as disintegrating mills in this discussion.

Disintegrating Mills

About ten years ago inventors seem to have busied themselves with the question of dispersing solid hydrocarbons in oil to make liquid fuels, and while frequent references may be found in patent specifications of the time to "high-speed mills," details of such machines seem lacking,[10] although one optimistic colloidal fuel inventor desired to use a machine having a linear speed of 1000 meters per *second*.

A few words as to the distinctive methods of obtaining the hydraulic shear forces may be of interest. In the Plauson machine it is generally understood that a combination of shearing stresses and impact forces effect the disintegrations, the revolving blades leaving and re-entering the space between adjacent fixed blades with such rapidity as to impart suffi-

[10] Hurrell, *Chem. Age*, **10**, 440 (1924).

cient shock to the liquid in the thin film to disrupt and disperse the suspended matter.

Mills which depend wholly upon the shearing of a liquid film, adhering with great tenacity to the relatively fast-moving confining surfaces, may be divided into two distinctive classes: (1) Those in which the liquid is propelled through the gap by the centrifugal forces acting upon the material forming the film. They include machines having the working surfaces in the form of discs or flattish truncated cones, diverging from the ingress end. (2) Those in which the surfaces confining the film are so shaped that the film does not tend to evacuate the space by its own inertia, or in which it actually tries to work back to the feed space. Both modifications of the second class are incorporated in the Hurrell Homogenizer.

The disintegration is due to hydraulic forces, the film of liquid being sheared under pressure like a solid, the particles in the line of shear becoming disintegrated.

The film gap is cylindrical or nearly so; in this way the linear speed is a constant quantity at any speed of rotation, differing in this respect from mills having, as working surfaces, discs or shallow cones.

Without going into too much detail, it may be mentioned that the machine has a short cylindrical-jacketed stator, flat end covers, each carrying a gland and ball bearing, a rotor almost fitting the bore of the stator, and having an arrangement of radial passages at mid-length, by means of which the liquids reach the film space at a pressure determined by the radial depth of liquid being whirled around, and this depth automatically responds to the rate at which materials are delivered to the hopper. In practice the pressure varies from a fraction of a pound to about 100 lbs. per square inch. The rotor is carried centrally between the bearings on a horizontal shaft, and the whole machine is traversed along its bedplate to adjust the belt. In spite of the high film pressure prevailing (aggregating many tons), absolutely no end thrust is set up owing to the central feed and the equal discharge in both directions.

Machines permitting of adjustment are made with very slightly tapered working surfaces, and a longitudinal displacement is effected by a screwed housing which opens or closes the gap $^{1}/_{1000}$ inch per half turn. The set minimum clearance (generally $^{2}/_{1000}$) cannot be passed and the metal surfaces never touch. The adjustment can be effected with the machine running at full speed.

The disintegrating mill is adapted for the economical dispersion of solids, plastics, or liquid masses into particles whose dimensions, as a rule, are one micron or less in diameter. Solids are, as a rule reduced to subdivisions that pass through filter paper. The dispersion occurs within the liquid medium, so the disruptive action is caused without contact of the surfaces of the rotor; that is, the action upon the surfaces of the rotor and

stator is practically nil, but one should never use a finer clearance or higher speed than is required to do the work.

The materials to be emulsified or dispersed are fed by gravity to a funnel mounted on the inlet. In the case of liquids for emulsification, they should be run in as two streams, regulated as to proportion. Solids in powdered form are usually shaken onto a stream of water constantly running into the funnel. Solids already in suspension are simply fed at the required rate to the hopper.

The thoroughness of treatment varies with the rate at which the substances pass through the machine. To secure any desired rate it is merely necessary to deliver the materials at that number of gallons per hour to the hopper. The machine automatically regulates the rate of passage through the gap. A minimum rate of about 3 per cent of the maximum is possible.

Solids should first have a preliminary grinding so they will at least pass an 80-mesh screen, unless they are of a very soft nature, *e. g.*, like paper pulp, when this is not necessary.

Materials of Construction.—The standard material is cast iron throughout, except the shaft which is of high tensile steel. Where traces of iron oxide would be detrimental to the product, or where the materials being treated attack cast iron, the whole of the interior is lined with sheet metal, such as pure nickel, monel metal, copper, or aluminum, and the rotor and glands are of monel metal, nickel, chrome alloy, or cast aluminum.

General Uses for Disintegrating Mills

As an example of some of the many uses to which a disintegrating mill of proper design may be put in commercial operations, the following are typical:

(*a*) Emulsification of vegetable, animal, and mineral oils, resins, waxes, etc.

(*b*) Manufacture of water paints and distempers.

(*c*) Incorporation of pigments in the more fluid enamels and paints.

(*d*) Preparation of reconstituted milk from milk powder and sweet butter.

(*e*) Extraction of oils, fats, resins, juices, etc., from vegetable or animal tissues.

(*f*) Extraction of fibrous materials.

(*g*) Purification of certain organic chemicals, liquid and solid.

(*h*) Intimate mixing of the ingredients of meat extracts and the reduction of size of particles; increasing the solubility of some and making finer suspensions of the insoluble ones.

(*i*) Intimate mixing of creams, sauces, and other foodstuffs.

(*j*) Homogenization of fat globules of milk, improving its consistency and digestibility, as well as its fitness for ice cream.

(*k*) Disintegration of solids, such as mica, oxides, barytes, rock phosphate, calcined bone, china clay, pigments, metal powders, pitch, coal, dyes, and a vast number of other products.

Specific Cases

While the above is more or less of a general list it might be well at this time to deal with some specific cases—take, for example, the paint industry. An accurate knowledge of the percentage distribution of the various sizes of particles of colloidal material is one of the fundamental requirements in the control and improvement of paints, dyestuffs, rubber, etc. If we study the effect of varying the size of particles of the pigment on its properties, we discover at once that obscuring or hiding power, oil absorption, capacity, permeability, consistency, and the rate of disintegration of the paint film by sunlight are altered. While the degree of subdivision is not the only factor, it is a contributing one. Of the methods used in the determination of particle size, that of studying the system and obtaining the distribution relation by the application of Stokes' law of sedimentation is about the most satisfactory. Sedimentation by gravity, however, is time consuming, so by using centrifugal force we may determine the distribution more conveniently.

Again, as a result of increase of dispersion and surface area in the dispersoid, chemical reactions are speeded up and in a large number of cases become almost instantaneous. Very often impurities may be removed from oils by emulsification followed by the breaking of the emulsion, when the impurities remain in the water phase with the emulsifying agents. An example of this is the production of carbolic and cresylic acids from tar oils, the carbolates and cresylates separating upon the breaking of the emulsions. Other specific uses are:

Grinding of Fibers.—The preparation of paper pulp and fiber for roofing felts and paper stock. The recovery of pulp from old newspapers. (In the latter process the newspaper-magazine stock is disintegrated and de-inked in one operation by addition of proper solvents to the water medium.) Rag fibers are transformed into a smooth mass with a uniform distribution which eliminates the manufacturing loss from "lumps" and produces increased tensile strength in the final product. The material is also more susceptible to saturation with sizings, etc.

Selective Separations.—The application of selective disintegration for purification is important for removal of impurities in graphite, clays, etc.

Disintegration.—The preparation of suspensions of iron oxide for wet process gas purification. Other substances such as glass for enamels, colloidal coatings for paper filling and sizing, colloidal salts of silver for photographic processes, phosphate rock, sulfur, clays, printing and litho-

graphing inks, the so-called colloidal dispersions of coal and pretroleum residues in fuel oils, graphite in lubricating oils, etc., are prepared in this manner.

Pharmacological Preparations.—Colloid substances are coming more and more to the front in pharmacology. This is especially true where they are very fine-grained and therefore approach nearly to true solutions. The hydrosol of silver has valuable antiseptic properties, and the hydrosol of mercury has proved to be useful in dermatology. Milk of magnesia is made by a direct process by using a pure grade of light calcined magnesia which can be hydrolyzed and put in permanent suspension by observing proper precautions.

The extraction of vegetable tissues to obtain essential oils, tannin, ginger, alkaloids from barks, etc., can be effected in this way. When any material of a fibrous nature (providing it is not tough) is passed through the mill the disintegrating forces tear the fiber to pieces and expose the tissues to the disruptive action of the liquid medium. This is true for all meat and animal tissues and most vegetable tissues. The whole of the soluble content goes into the liquid phase and the fibers remain free and colorless.

Bearing of Colloids on Agricultural Chemistry.—It has been difficult to explain many of the processes which go on in the soil by physical or chemical means alone. Much valuable work on the chemistry of soils, of fertilizers, and of plant growth has recently been done. Colloidal theories of matter have proven invaluable in interpreting the results obtained. There are present in the soil in colloidal state the hydroxides of silicon, iron, and aluminum, and especially humus, which plays such an important role in plant growth. The adsorption of the various constituents of fertilizers by the soils, and the imbibition of water in the soils, are probably directly connected with the presence of so-called colloids in the soil. These colloids arise largely from the weathering of rocks and from the decay of organic material.

Bearing of Colloids on Mineralogy.—Many minerals are really gels. Thus, opal, bauxite, and many other minerals belong in this class.

Tanning.—The process of tanning is also largely dependent upon colloidal properties of matter. The albumin of the skin takes up water, the amount depending upon the nature of the electrolyte present. In the presence of certain acids enormous amounts of water are thus taken up. The most readily adsorbed colloids are deposited on the surface of the leather, the less readily adsorbed diffusing into the leather. By suitable choice of tanning liquid, the skin is tanned to different depths.

Dyeing.—Another technical process in which colloids play a prominent role, is the art of dyeing. Many of the dyestuffs are colloids and many of the substances dyed exhibit the colloidal property of imbibition. Among

the colloidal dyes are such substances as Congo red, Congo brown, benzopurpurine, aniline blue, etc.

It might be well to add, that while the dispersion mills have a very extensive field for their application, it is important to bear in mind that no matter how excellently a machine may do its work, a proper understanding of emulsifying agents, etc., is necessary for satisfactory operation. The machine, itself, is about 60 per cent responsible for the success of the process; the other 40 per cent depends upon the knowledge and judgment of the operating chemist.

Theory of Emulsions and Emulsification

For the past twenty years emulsion has been the subject of lively comment in chemical literature, and while no general theory of emulsification has been elucidated, many have been proposed from time to time, only subsequently to be shown to apply to special cases. There is, however, a mass of arbitrary data which can be profitably applied.

An emulsion is a system containing two liquid phases, one of which is dispersed as globules in the other. That liquid which is broken up into globules is termed the dispersed phase, while the liquid surrounding the globules is known as the continuous phase or dispersing medium. The two liquids, which must be immiscible or almost so, are frequently referred to as the internal and external phases, respectively. In the case of an emulsion where oil and water are used, we speak of it as an oil-in-water emulsion or a water-in-oil emulsion. In the case of the oil-in-water emulsion, the oil is dispersed in the water, the water being the continuous phase, while in the water-in-oil emulsion, the reverse is the case.

Clowes[11] found that sodium, potassium, and lithium soaps emulsify oil in water while magnesium, strontium, barium, iron, and aluminum soaps emulsify water in oil. Soaps of the first series contain monovalent metals and are soluble in water but not in oil, while the second series contain bi- and tri-valent metals and are soluble in oil but not in water. In other words, alkali soaps are wetted more by water than by oil, and probably the surface tension is lower on the water side than on the oil side of the globules, so the film will bend convex to the water and concave to the oil, enveloping the oil globules as the area of the inner surface of a sphere is less than that of the outer. Similar reasoning holds for the reversing of the emulsion by the other soaps mentioned, which are more soluble in the oil.

The Viscosity of Emulsions.—The theory regarding the viscosity of emulsions, from a quantitative point of view, is far from satisfactory, very little work having been done in this connection. Dilute emulsions show a viscosity not much greater than that of water. Viscosity increases

[11] *J. Phys. Chem.*, **20**, 407 (1916).

rapidly as the volume of the dispersed phase increases, but in this case, of course, there arises the new factor of the emulsifying agent.

The viscosity of concentrated emulsions is intimately connected with the presence of adsorbed films around the dispersed globules. This is particularly evident in the homogenization of emulsions, *i. e.*, the increased dispersion of the internal phase, whereby the presence of the adsorbed emulsifying agent at the greatly magnified interface confers a marked increase of viscosity to the system.

Pickering[12] noted that emulsions were poor conductors of heat. It is possible to boil a beaker of such an emulsion for several minutes, while the center remains at less than 100°C. When kept in closed vessels they are permanent for months.

The adsorbed ions are considered to be concentrated near the surface of the globules, in the layer of the liquid immediately bathing the globules. The two layers of oppositely charged ions are frequently referred to as the Helmholtz double layer. The oil globule and its double layer may be considered as a small condenser, a definite potential difference existing between the oil and the nearer ionic layer, thus giving proof that they are negative. The fact that the dispersed particles do carry electrical charges is most important when we come to the question of the stability of any emulsion.

Stability.—For emulsions of oil in pure water the stability is influenced by (*a*) the interfacial tension, tending to bring about coalescence of the globules, whereby the total surface would be reduced, (*b*) the Brownian movement, tending toward collision of the globules, a factor operating against stability; and (*c*) the electrical charge on the globules, tending to repel them from each other on near approach.

Most of the work on emulsion stability relates to the influence of added electrolytes. When colloid particles are coagulated under the influence of electrolytes, the globules adsorb oppositely charged ions, so that their charges become neutralized and, at the iso-electric point, where the potential difference between the particles and the medium become zero, stability is least.

The work of Donnan[13] on neutral oil emulsions shows that there is a close similarity between such "mechanical" emulsions and colloidal suspensions. In each the particles carry an electrical charge of the same order of magnitude, the limiting grain size is similar, the potential difference values are similar, and the conditions for stability under the action of adsorbed ions are also similar. Thus the electrical factors outweigh the effect of interfacial tension.

Brownian Movement in Emulsions.—Suspensions of fine particles, fine-grained emulsions, and colloidal solutions of metals all show when

[12] *J. Chem. Soc.*, **91**, 2002 (1907).

[13] *Zeit. Phys. Chem.*, **46**, 197 (1903).

examined under the ultra-microscope, that the particles of the dispersed phase are in continuous zigzag motion. The phenomenon is termed the Brownian motion, after Brown,[14] who studied the movements of pollen grains in water. It is now known that the movements of finely divided particles suspended in liquids are due to the bombardment of the particle by the molecules of the surrounding liquid. This Brownian movement is not observed before the particles are split to a very finely divided state; usually below 2μ in size.

Water-in-Oil Emulsions.—Calcium and aluminum soaps are used in lubricating greases. Such greases are, as a rule, solutions of lime soaps (15 to 25 per cent) in heavy mineral oil with 1 to 4 per cent water emulsified in them. Some lubricating greases for automobile use consist of aluminum soaps dissolved in mineral oils with water emulsified in them by the aid of rosin.

Oil-in-Water Emulsions.—The most common emulsions are those in which the oil is dispersed in the water. In all emulsions where the concentration is over 2 per cent it is necessary to have a third substance present, which is known as the emulsifier or emulsifying agent. For example, in the case of a dairy emulsion, such as butter fat dispersed in milk, casein is the emulsifying agent, while in the case of a chocolate emulsion where the cocoa fat is emulsified in the chocolate liquor, fine particles of cocoa powder which accumulate about these fine globules of cocoa fat act as the emulsifying agent.

Water-Soluble Colloids as Emulsifying Agents.—Good emulsifiers of this class are sodium and potassium soaps, egg albumin, gelatin, glue, and other water-soluble proteins, gum arabic, Irish moss, casein, starch, saponin, and various bark extracts. NaOH was classified as an excellent emulsifying agent for fatty oils in water, but Donnan's[15] investigation showed that its emulsifying powers were really due to the soap formed by interaction with the small amount of free fatty acid that is always present in fatty oils.

There is a very simple method of determining the type of emulsion. Water added to an emulsion of oil-in-water will disperse. Similarly, a water-in-oil emulsion will mix with oil. In short, an emulsion will mix with more of the constituent which forms its external phase, but not with that which forms its internal phase.

The Electric Charge.—The oil globules in emulsions of oil in water carry a negative charge, as proved by cataphoresis tests. The origin of this charge is still open to question, as is, indeed, the more general case of the electric charge on all colloid particles.[16] The electric charge is believed

[14] *Phil. Mag.*, **4**, 161 (1828).

[15] *Zeit. Phys. Chem.*, **31**, 42 (1899).

[16] See, however, Michaelis, "The Effect of Ions in Colloidal Systems," Williams & Wilkins Co., Baltimore, Md., **1925**, pp. 29–50.

to be due to the adsorption of ions. In the case of emulsions bearing a negative charge, adsorption of hydroxyl ions at the surface of the oil globules is postulated. Even when emulsions are made with absolutely pure oil and pure water there should be present hydrogen and hydroxyl ions due to the ionization of the water.

The Stability of Emulsions.—We have already noted that concentrated emulsions demand the presence of an emulsifying agent. In such cases the stability of the emulsion depends on factors relating to an adsorbed film at the oil-water boundary.

Homogenizers

The first uses of the homogenizer were confined to the dairy industry and date back to about 1905, when the homogenization of dairy products such, for example, as evaporated milk was undertaken. Its purpose was just the reverse of that of a cream separator. Instead of separating the fat from the milk it was possible with the homogenizer to incorporate fat into the milk, thereby making any percentage of cream desired up to as high as 40 per cent or what is known as heavy cream. After the homogenizer had worked successfully in this field for a few years, it was next introduced into the ice-cream industry, where it was used to incorporate the fat, milk solids, etc., into a homogeneous mass, and develop a smooth ice cream which brought about a big improvement in the product. The practice of homogenizing was confined to the two above-mentioned industries for a number of years and it is only rather recently that machines have been effected capable of making fairly perfect emulsions of oils, fats, etc., with water.

The present generally accepted theory of the formation of homogenized emulsions postulates the presence of a stabilizing film around the dispersed phase which prevents the particles from coalescing when they come into contact with each other, due to the Brownian movement. This protecting film is the emulsifying agent used, which surrounds each particle of the dispersed phase of the emulsion. As these particles are so finely broken up that they take on Brownian "motion" they are, of course, little affected by gravity.

Change in Size of Fat Globules.—Wiegner[17] in his studies on homogenized milk, investigated the change in the diameters of the fat globules and the increase in their numbers following homogenization.

It is of interest to mention the globule sizes of some typical three-phase emulsions for the purpose of comparison. Baldwin[18] found that the butterfat globules in cow's milk were from 0.005 to 0.006 mm. diameter (5 to 6μ). By homogenizing—*i. e.*, further sub-dividing—the diameters were reduced to 1 to 2μ.

[17] *Koll. Zeit.*, **15**, 105 (1914).
[18] *Am. J. Pub. Health*, **6**, 862 (1916).

It is reported that the diameters of the fat globules have been reduced from 2.86μ to 0.27μ and from 2.94μ to 0.17μ, the sample with the smaller fat content being split into a finer state of division. The number of particles in the first sample has increased 1188 times and in the second sample 1258 times, after homogenization. The surface area of the fat globules has been increased 112 and 117 times, respectively. There was no apparent change in density and no difference in electrical conductivity, although Buglia[19] in similar work noted a slight increase in the electrical conductivity of homogenized milk. Both Wiegner and Buglia find that there is a slight decrease in osmotic pressure following homogenization.

[19] *Koll. Zeit.*, **12,** 353 (1908).

New Rays Fill Unknown Gap. Another gap in the spectrum of radiation, which includes light, X-rays, radio waves and the very short rays investigated by Millikan, has now been filled, it was recently announced by Wynn Williams of the University of North Wales. He has been making investigations of sparking between electrodes and accidentally found the new rays, which are believed to fill part of the gap between the longer X-rays and the short ultra-violet rays, which lie beyond the violet in the visible spectrum. It is stated that the new rays will penetrate air for several meters and will go through thin celluloid films, but are stopped by solids such as gold leaf and even thin mica.—*Science Service*

Blood Cells and Glands Contain Cure for Rickets. New cures have been found for rickets, a serious disease of children and young animals due to defective bone structure, in three substances commonly found in the bodies of all animals. They will be reported by Dr. Andor de Bosanyi in the next issue of the Bulletin of the Johns Hopkins Hospital.

Rats afflicted with rickets were fed on a diet containing hemoglobin, which is the red coloring matter found in blood corpuscles. When the diet contained from five to six per cent by weight of this material the rats were quickly cured of their rickets.

A previous experimenter had stated that a substance very similar to hemoglobin would cure rickets when the subject treated was exposed to light. In order to determine whether or not light had any influence in the cure caused by the hemoglobin, rachitic rats were fed the diet containing hemoglobin for eight days in a light-proof compartment. There was found to be quite as marked healing as in the presence of light.

Adrenalin, a substance secreted by glands lying immediately above the kidneys, and known to be a very powerful heart stimulant, was next given to the rats. Very weak doses were given at first and the strength of the dose increased until after four or five days the rats were taking at one dose an amount which would have proved fatal before. Healing of the rickets then began and proceeded rather rapidly until all symptoms disappeared.

The third curative substance was found in histamine, which is a decomposition product of proteins, those complex nitrogenous compounds that form the foundation of all living things. Rats on a histamine diet were cured of rickets in from six to eight days.—*Science Service*

CLEVELAND SCHOOLMASTERS' CLUB COMMITTEE REPORT ON SCIENCE*

COMMITTEE:

ELLIS C. PERSING, *Chairman*, DEPARTMENT OF NATURAL SCIENCE, CLEVELAND SCHOOL OF EDUCATION, CLEVELAND, O.

CHARLES A. MARPLE, DEPARTMENT OF PHYSICS, CENTRAL HIGH SCHOOL, CLEVELAND, O.

C. H. SALTER, DEPARTMENT OF CHEMISTRY, LAKEWOOD HIGH SCHOOL, LAKEWOOD, O.

HENRY P. HARLEY, FAIRMOUNT JUNIOR HIGH SCHOOL, CLEVELAND, O.

Curriculum Practices in Science Grades 1 to 12

The report of your committee last year indicated the need for further study, dealing with the problems of the sciences in the curriculum. What are the objectives of the sciences? Has any one definitely set up the needs of the pupil—grades 1–12—in the field of natural sciences? In what way is the content of our science courses determined? Is the science offered in grades 1–12 meeting the needs of our pupils today?

The Science Committee decided to continue their work by making a study of the present curriculum practices in science grades 1–12. In order to do this, an attempt was made to cover the literature for the last 10 years and gather other necessary data by the questionnaire method.

Science in this study is considered under three heads:
Elementary Sciences—Grades one, two, three, four, five, and six.
Junior High-School Science—Grades seven, eight, and nine.
Senior High-School Science—Grades ten, eleven, and twelve.

Elementary Science

It was the original plan to put out a questionnaire covering the work in elementary science, but the committee learned that The American Nature Study Society was planning a comprehensive study of science in the grades. For that reason your committee decided to await their report and continue in other fields. The report of the American Nature Study Society Committee is now available. Section I contains the report on the status of nature study in city schools.

Preliminary Report of Committee on School Progress—Miss Clerla Paroni, *Chairman*. This was a questionnaire study.

The report includes data for 127 cities of five thousand population and over. In fifty-three cities nature study is being taught or, as the report states, fifty-three cities "professed to be teaching nature study definitely." Twenty-two of the fifty-three cities have supervisors of nature study. Fifteen cities do not have courses of study.

* Delivered at the May 26, 1925, meeting of the Cleveland Schoolmasters' Club, Cleveland, Ohio.

The average weekly time for science in the elementary school is thirty minutes. Many cities are providing science rooms in each building. The needs as shown by this report are as follows:

1. Better trained teachers.
2. Arrangements for doing field work.
3. Materials, such as mounted exhibits, pictures, charts, slides, etc.
4. Definite time on the program.
5. Supervision, as in art, music, and other school subjects.
6. Aims more definitely defined, and definite courses.
7. Department teaching with special teachers for nature study.
8. School gardens.
9. Nature readers.
10. Support of the public.

This report seems to indicate a number of problems for further study.

Curriculum Practices in the Junior High School and Grades 5 and 6

James M. Glass

One-half of the fourteen centers included in this study require science in the fifth year. Two cities require science in the sixth year. In one center, Atlanta, gardening is combined with nature study, and in another, Los Angeles, agriculture is combined with nature study in grades 5 and 6. The report states that nature study is the predominating type of science in the elementary grades.

In the summary the report states that "the distinction in nomenclature (nature study, elementary science) will disappear as articulation progresses, and science will be used to designate a continuous course of a science constant through the elementary school and junior high school and into the senior high school at least as far as other constants are offered."

Junior High School

The committee decided to learn the current practices by means of a questionnaire and the few available reports on current practices in science for the junior high school.

A questionnaire was sent to 250 junior high schools in cities having a population of 2500 and over, as listed by the Bureau of Education.[1] Replies were received from 103 schools.

Table I indicates a greater number of sciences offered in grade 7 than any of the other grades. The reason for this is not in any way indicated by the replies. In grades 7 and 8 a greater percentage of schools requires science than in grade 9. In grade 7, 70 per cent of the schools offer science.

[1] City School Leaflet No. 12, September, 1923, Bureau of Education, Washington, D. C.

In grade 8, 86.6 per cent of the schools offer science. In grade 9, 84.3 per cent of the schools offer science. In the 60 schools offering science in grade 7, 90 per cent require science. In grade 8, 100 per cent of the schools

TABLE I. THE NUMBER OF SCHOOLS AND THE SCIENCES TAUGHT

Year	Subjects	No. of schools	No. of schools requiring science	No. of schools offering science as an elective
7	Geography	26		
	Physiology and hygiene	10		
	General science	21		
	Elementary science	1		
	Agriculture	1		
	Nature study	1		
	No answers	16		
	No science	27		
	TOTAL	103	54	3
8	General science	64		
	Geography	4		
	Physiology and hygiene	3		
	No answers	21		
	No science	11		
	TOTAL	103	71	8
9	General science	55		
	Biology	26		
	No answers	7		
	No science	15		
	TOTAL	103	44	31

offering science require it. In grade 9, only 54 per cent of the schools offering science require it.

Table II shows the number of pupils per class and the average number of classes. Your committee had hoped to get some information on the lab-

TABLE II

Year	School enrolment	Pupils per class	No. of classes	Length of periods	No. of laboratory periods	Length of laboratory periods
7	Range 66–1066	21–46	0–28	30–60	0–5	40–135
	Average 335	34.2	8.1	50.81	3	62
8	Range 20–1500	17–45	0–32	30–60	0–5	40–120
	Average 402	31.3	7.08	49.6	1.4	52.5
9	Range 19–3500	19–41	0–42	30–85	0–5	45–120
	Average 434.3	33.5	6.6	51.2	1.58	58.1

oratory activity. The range of time might be misleading since many schools do not have separate time for a laboratory period. The average length of the laboratory period indicates that most of the laboratory work

is done in a regular period. Four schools, out of the whole number reporting, show more than a single laboratory period per week.

The findings as shown in Table III would indicate that natural science is

TABLE III. COMPARISON OF SCHOOL ENROLMENT WITH THE NUMBER OF PUPILS TAKING SCIENCE

Year	Enrolment	Classes	Pupils taking science (%)
7	21,137	483	80.2
8	28,444	595	65.4
9	27,465	456	55.6

becoming established as a subject along with other subjects in the junior high-school curriculum.

No attempt was made to collect courses of study, but the text-books used may be taken to indicate subject-matter included in each grade. Many schools did not list the text-book used but, of those reporting, geographical subject-matter holds the field in grade 7, with general science a close second. The text-books used would indicate a great variety of subject-matter. Ten schools do not use a text-book.

In grade 8 there is greater uniformity of subject-matter as indicated by the texts used. One school uses a biology text and one school uses a hygiene text-book. All the other text-books for grade 8 cover some type of general science. Nine schools do not use a text-book for this grade.

In grade 9, biology and general science are the sciences taught. The text-books used would indicate considerable variety of subject-matter. This may be due in some cases to local conditions. Four schools are teaching science in the 9th year without a text-book.

In Table IV, 78 schools seem to indicate satisfaction with the present sequence of science in the junior high schools and 26 suggest changes.

TABLE IV. ANSWERS TO FIVE LAST QUESTIONS

What changes would you make in the sequence of the sciences in your school?

Schools reporting	Answers
35	No answer at all
33	No changes
1	More recitations per week, less time for course
1	More laboratory work
1	Physiology separate in 7th grade
2	Physiology with general science in 9th grade
4	All general science in 9th grade
1	Use general science as prerequisite for biology
7	Some science in each of 7th, 8th, and 9th grades
1	7th, geography, 8B; physiology and hygiene
8	Physiography, 9th grade, general science
1	More geography
1	General science and biology
3	Biology in 9th year instead of earth science

TABLE IV (*Continued*)

Schools	Answers
2	Biological science be taught before non-biological
1	More library work
1	General science, grade 9; biology, grade 10

How do you seek to stimulate initiative on the part of the pupils in their laboratory work?

Schools	Answers
18	Unclassified answers
16	No answer at all
9	No laboratory
2	Extra credit
3	No equipment
2	Illustrations from papers and magazines; have pupils see connection between report and lesson
3	Pupils do their own experiments
4	Relating it to familiar things around them
1	Arousing pride in note-books
2	Hikes, collections, visiting plants, note-books
5	Outside project work
6	Allowing pupils to suggest demonstrations; and suggesting simple experiments to be done at home
2	Science club
3	Get material outside
1	By making work a discovery for them
4	Select groups to demonstrate before class
3	Individual laboratory work leading either to competition or to some coöperative project
1	Draw from pupils' experience
6	Individual or group projects
8	Allowing pupils to suggest problems
4	Demonstration experiments

Have you had experience in teaching science without regular laboratory work?

Schools	Answers
37	Yes

What success did you have?

Schools	Answers
3	Did not answer the question
5	Very good success
9	Good success
8	Fair
5	Not satisfied
4	Very little success
1	Practical for lower grades
1	Found pupils forgot vital points
1	Not sure

What proportion of time do you give to the application of scientific principles and processes in modern industry?

TABLE IV (*Concluded*)

Schools	Proportion of time
1	Almost none
3	1/10
1	1/9
9	1/5
7	1/4
3	1/3
10	1/2
2	3/4
1	As much as possible
66	No answers

Senior High School

The data on enrolment in the senior high school were obtained from the Bureau of Education, Washington.

Table V shows the changes in science enrolment during the past thirty years. The old stand-bys, astronomy and geology, are practically gone and several newcomers have taken their places. The most phenomenal gain is shown in general science. In 1915 there were so few taking it that no statistics were compiled. In 1922 the enrolment in the subject was 394,000. Hygiene and sanitation, a new subject, has had a rapid growth. The decrease in physical geography can doubtlessly be explained by the increase in general science.

When we consider the total enrolment in the high schools, however, only the following sciences have shown a gain in per cent: biology, chemistry, general science, hygiene, and sanitation.

The whole tendency in science apparently, is to drop the highly theoretical sciences and to make the courses offered more practical.

A recent study by Hunter[2] reviews the recent literature and includes the data from 368 replies of representative schools in 33 different states. This report indicates a definite sequence of general science, biology, physics, and chemistry. Biology as a year course is tending to displace botany and zoölogy. Biology in the 9th grade has increased from 10 per cent of the science courses in 1908, to 16.1 per cent in 1923 and in the 10th grade from 7.3 per cent in 1908, to 47.1 per cent in 1923. Chemistry has made a marked increase in the number of courses offered since 1908. The increase in physics is not so great. Physiography, which was a leading first-year subject in 1908, is tending to become an advanced course in the twelfth year.

Summary

The need for elementary science is indicated by the movement to reorganize science and nature study in the elementary school.

[2] G. W. Hunter, "The Place of Science in the Secondary School," *Sch. Rev.*, 33, 370–81 (1925).

TABLE V. STUDENTS ENROLLED IN THE SCIENCES SINCE 1890

Year	1890		1895		1900		1905		1910		1915		1922	
Science	Pupils	Per cent of Total	Pupils	Per cent of Total	Pupils	Per cent of Total	Pupils	Per cent of Total	Pupils	Per cent of Total	Pupils	Per cent of Total	Pupils	Per cent of Total
Astronomy			16,770	4.79	14,435	2.78	8,307	1.22	3,915	0.53	3,224	0.28	1,474	0.07
Biology											80,403	6.90	189,288	8.78
Botany									124,380	16.83	106,520	9.14	82,241	3.82
Chemistry	20,503	10.10	32,020	9.15	40,084	7.72	45,980	6.76	50,923	6.89	86,031	7.38	159,413	7.40
Geology			17,488	5.00	18,743	3.61	15,914	2.34	8,538	1.16	5,558	0.48	3,520	0.16
General Science													393,885	18.27
Hygiene and Sanitation													130,728	6.06
Physical Geography			83,642	23.89	121,335	23.37	146,275	21.52	142,948	19.34	169,911	4.58	92,146	4.28
Physics	46,184	22.21	79,720	22.77	98,846	19.04	106,430	15.66	107,988	14.61	165,854	14.23	192,380	8.93
Physiology			104,862	29.95	142,401	27.42	149,262	21.96	113,252	15.32	110,541	9.48	109,519	5.08
Zoölogy									59,253	8.02	37,456	3.21	32,956	1.53
Total number of high-school pupils	202,963		350,098		519,251		679,702		739,143		1,165,495		2,155,460	

General science has expanded and replaced the nature study of grades 7 and 8. Science is becoming established as a subject along with other subjects in the three years of the junior high school.

There is a tendency to articulate the science of elementary school, junior high school, and senior high school. The increased interest in science and the great increase in enrolment would warrant a study of some of the problems suggested by this and other studies.

Chestnut Stumps Rich in Tannin. The stump wood, root wood, and root bark of the American chestnut tree are very rich in tannin. This is a discovery recently made by chemists of the United States Department of Agriculture. On the average sound root, they say, the bark was found to contain more than 30 per cent of tannin, and root wood more than 17 per cent. This yield is fully twice as great as that obtained from the trunks and limbs of the tree, now our most important domestic source of tannin for commercial use.

With reference to the horizontal distribution of tannin, these chemists also found that the edge of the heartwood of the stump and trunk is much richer in tannin than is the central zone of the heartwood. This indicates that from a given stand of chestnut, slab wood will furnish a higher yield of tannin than will the remainder of the wood.

This work suggests the possibility of increasing our domestic supply of tannin through the commercial utilization of chestnut stumps, roots and slab wood, particularly the slab wood selected from trunk and butt logs. There are some difficulties in the way of the commercial use of the stumps which weigh against their high tannin content. Among these are labor costs, value and nature of land, method of handling wood supply, quantity of stumps, size and shape of stump and root pieces, with consequent difficulties in transportation and preparation.—*New York Commercial*

Relieves Dropsy with Sal Ammoniac. Sal ammoniac, administered to humans in portions of one-third of an ounce a day, has been used effectively for the treatment of dropsy, according to a statement made by Dr. N. M. Keith, of the Mayo Foundation, at Rochester. This complaint, known technically as oedema, is essentially the unnatural accumulation of fluid in the tissues. It is frequently associated with liver and kidney disorders.

"We are giving ammonium chloride by mouth in capsules at the rate of 10 grams a day," said Dr. Keith. "The result is a pronounced increase in the fluid eliminated by the body. In this way we are able to get rid of water in the chest."

Combinations of ammonium and mercury salts have been used also in difficult cases, when neither salt separately served.

"The effectiveness of the ammonium chloride is likely due to the splitting up of the compound," Dr. Keith said. "The chlorine is converted into hydrochloric acid, and in this form it increases the acidity of the blood. The ammonia appears as urea." Urea is the usual form in which nitrogen is excreted by the body.

A similar excessive elimination of water has been noticed in normal individuals after an ammonium chloride meal by Dr. J. B. S. Haldane, at Cambridge, England, but the method has not previously been utilized in disease, it is stated.—*Science Service*

Chemical Digest

CHEMISTRY IN THE EARLY DAYS OF THE RENSSELAER POLYTECHNIC INSTITUTE*

In a letter to the Rev. Dr. Blatchford, dated November 5, 1824, Stephen Van Rensselaer wrote: "I have established a school at the north end of Troy for the purpose of instructing persons in the application of science to the common purposes of life.....the application of experimental chemistry, philosophy and natural history, to agriculture, domestic economy, the arts and manufactures."

The choice made by the Patroon of Rensselaerwyck of a suitable person to head the new school was singularly fortunate. He selected Amos Eaton, one already known to science, an author and lecturer well versed in things chemical, a man who had given thirty courses on his chosen subject, each illustrated by six hundred experiments, before he became connected with the new educational venture.

Van Rensselaer's first movement was to send Professor Eaton with a competent corps of assistants to traverse New York State along the route of the Erie Canal with sufficient apparatus, specimens, and the like to deliver in all the principal towns, where an audience could gather, familiar lectures with experiments and illustrations on chemistry, natural philosophy and natural history. This was designed to arouse a widespread popular interest, and the experiment was successful.

Amos Eaton's name looms large in the history of education of a century ago. He was, as already stated, the senior professor at the very starting of Rensselaer and he taught chemistry, together with other branches such as geology, physics, and natural history, a combination which was retained in many schools for many years. The field of knowledge was rather restricted in those days and it was often considered uneconomic to assign a teacher to cover one subject only.

That Rensselaer's first professor of chemistry had the ability to impart what he knew has been attested by those who sat at his feet and who never seemed to tire of recounting incidents of the lecture and class-rooms where the great teacher held the attention of his students firmly fixed with a power which we of today so often long for but so seldom attain.

In his "Chemical Instructor," which appeared in 1822, Amos Eaton says: "I have endeavored to bring down the sublime science of chemistry within the reach of the laboring agriculturist, the industrious mechanic, and the

* Abstract of a paper read by W. P. Mason at the Ithaca meeting of the American Chemical Society, September 10, 1924.

frugal housekeeper. But in doing this, I hope I have not degraded the science by low or vulgar descriptions. I have made my descriptions more accessible to juvenile minds by writing, as I would talk, to a class of young persons whom I wished to instruct."

This early and able instructor maintained "that the teacher learns more in teaching than the scholar" and therefore he made each scholar a teacher of his classmates. It is interesting to note the following rule:

"When a student is giving a lecture, he shall have two auditors at least, to be appointed in rotation, who shall be critically attentive to him."

The system of "student lectures" which Amos Eaton introduced lasted for many years at Rensselaer, and those who gave that form of instruction were termed "repeaters."

From among the men who were taught chemistry by Amos Eaton there went out a group who taught in their turn and who carried his methods with them. John Torrey of Columbia University was one of these, and Chester Dewey, professor of chemistry at the University of Rochester, was another.

Amos Eaton started the first of the chemical courses given to women and among his early students was Mary Lyon, who afterward founded Mount Holyoke Seminary, now Mount Holyoke College.

Among the early graduates of Rensselaer, who established chemical courses elsewhere, we note Douglas Houghton, of the class of '29, who taught at the University of Michigan, John L. Riddell, of the same class, who established the chemical course at the University of Louisiana, Ebenezer Emmons, of the class of '26, who taught at Williams College, Michael Tuomey, of the class of '35, who taught at the University of Alabama, Ezra S. Carr, of the class of '38, who taught at the University of Wisconsin and later at the University of California, and E. N. Horsford, of the class of '38, who taught for many years at Harvard.

After returning from Germany, where he studied with Liebig, E. N. Horsford induced Abbot Lawrence to establish a school at Harvard devoted to Theory and Practice of Chemistry, whence grew the Lawrence Scientific School.

An earlier man than Horsford, James C. Booth, of the class of '31 at Rensselaer, was the first American to cross the sea to study chemistry in Germany. Upon his return, he established a laboratory in Philadelphia for Analysis, Research, and Instruction in Chemical Technology. This was the first institution of its kind in America and from it grew the widely known firm of Booth, Garrett, and Blair. Booth was the earliest alumnus, and for nearly half a century, the only one who bore the degree of Doctor of Philosophy from Rensselaer. He served as President of the American Chemical Society during 1883 and 1884, declining reëlection for 1885, and it is due to him to note that he was the first person in the United

States to propose the control of metallurgical processes by chemical rather than by rule-of-thumb methods.

S. R. House, of the class of '34, carried the chemistry learned at Rensselaer into distant parts indeed. He wrote: "Lectures on chemistry with experiments given soon after my arrival here (Bangkok, Siam) secured for me the respect and lasting friendship of the knowledge-loving Crown Prince, who a few years after was called to the throne and reigned for 17 years over Siam."

James Hall, of the class of '32, taught chemistry at Rensselaer in the early days and subsequently founded the Department of Chemistry in the University of Iowa, although he did not teach the subject there. For many years he was State Geologist of the State of New York.

Sundry of Rensselaer's early graduates became teachers of chemistry in high schools of the State of New York. To name only one, Fay Edgerton, of the class of '28, held such a position at Utica.

The chemical chair at Rensselaer, from 1855 to 1861, was held by William Elderhorst, a native of Celle, Germany. Upon his sudden death during a trip to Brazil, the vacant position was filled by another German, C. A. Goessmann. Both of these men were instrumental in sending graduates of Rensselaer to finish their chemical work in the German universities. Goessmann was in turn succeeded in 1864 by H. B. Nason, an old pupil of Wohler, under whom he studied at the University of Göttingen, Germany. Nason, who was an early President of the American Chemical Society, held the position of professor of chemistry at Rensselaer for many years, and for not a few of them, the present writer had the good fortune to act as his assistant.

For those who might be interested in the fact, let it be added that Dr. R. P. Baker, head of the department of English, at Rensselaer, has written a "History of the Work of Rensselaer Graduates" (Scribner & Sons).

L. C. N.

ABSTRACTS OF PAPERS TO BE DELIVERED AT THE TULSA MEETING

The Planning of a Chemical Laboratory

J. N. SWAN

The planning of an up-to-date chemical laboratory is more distinctly a research problem than many of the so-called research problems used in our laboratories.

This paper gives a discussion of the following general problems which meet the planner of a chemical laboratory. How many workers, faculty, and students, must the building accommodate? How much money must

be had, or how much building can be had for the money in hand? Chemistry is a changing science and calls not only for knowledge of the present but for a forward look. Usually the architects have had little or no experience in planning chemical laboratories.

These may be called outside or general problems. It is proposed to take up the inside problems in a later discussion.

Putting the "IS" into Chemistry

GUSTAVUS J. ESSELEN, JR.

The average young man or woman of high-school age today is a very practical sort of person. He or she is very much interested in the question covered by their own slang phrase, "What good is it?" In other words, they are, as a rule, much more interested in learning about something that is being used in the world in a practical way than they are in theories and principles. Unfortunately, to some teachers chemistry is chiefly reactions and theories, whereas everybody should realize that chemistry IS! which means that it is a living science and a vital, throbbing force in the practical life of today. A number of actual instances are given in which chemistry is playing a prominent part and a few suggestions offered for getting this thought that "Chemistry IS!" across to the students.

The Teaching of Qualitative Analysis

GEORGE W. MUHLEMAN

Every teaching problem is a research problem. The success of one's effort to present the subject of qualitative analysis must be measured by the number of students who continue in the advanced courses in chemistry. Many text-books have been written but few have been generally adopted. One of the chief aims of qualitative analysis is to develop technic. To do this the student should first learn how to read through the method of separating the ions after which he should be taught theory. Qualitative analysis is but a continuation of general chemistry. In learning the chemist's viewpoint, the student should develop judgment and good sense. Aids to this endeavor are found in interpreting color changes in solutions, writing all of the different kinds of equations, and interpreting phenomena by chemical theory. Quantitative ideas should be included in all work in this course. Some system in issuing unknowns and arranging reagents will save time and chemicals. A great deal of very effective tabulation can be done in this course.

Teaching the First Long Series

P. M. GLASOE

If the seventeen elements immediately following chlorine be arranged as follows:

K Ca Sc Ti V Cr Mn | Fe Co Ni | Cu Zn Ga Ge As Se Br

you can successfully teach each element in perfect consistency with its position. There is a very good gradation of properties from potassium to manganese and from copper to bromine. You do not have to apologize for the shortcomings of the periodic system nor explain away its inconsistencies. You expect mixed properties and valences in the region of Cr and Mn. Cu and Zn are consistent enough with their positions. You look for amphoteric properties all the way from Ti to Se *because of the position* and you are not disappointed in the facts. From a thorough study of the make-up of the long series a student should be able to predict the properties of the different elements even before they are taken up for study. This adds an element of curiosity that increases interest and furnishes a basis for retaining the facts.

Qualifications of a Chemistry Teacher

JAMES E. WILDISH

No one acquainted with present conditions will deny that much work needs to be done on the methods used in teaching chemistry, its place in the curriculum, its relation to other sciences as a whole, and its correlation with introductory college courses.

The most urgent immediate need is better qualified teachers. The most important step that could be taken to help conditions all along the line, would be to raise the standard of the teaching corps. Detailed syllabi, good text-books, elaborate equipment will not give desirable results unless they are in the hands of competent teachers. In dealing with the teacher this paper will stress such points as training (pedagogical and technical), personal traits, experience, and so forth.

Orientation of Students in Chemistry Aptitude as Tested by Results

C. A. BRAUTLECHT

In this paper the average results of an aptitude and chemical information test, given to over four hundred freshmen entering the University of Maine in 1925, are compared with the results in general chemistry

obtained during the first semester. It is shown that where no entrance examinations are required and admission is by certificate and preparatory school record, the real worth of a certificate may vary between wide limits with some schools. A placement examination is shown to yield information of a student's aptitude for the study of chemistry and knowledge of chemistry acquired through previous study. Reasons are considered for non-admittance to general chemistry of three out of six freshman students who had had no previous chemistry and had not made a grade of 50 in the aptitude examination; for the dropping of two with grades of 55 and 56 at mid-semester and the struggle of the remaining student to obtain a minimum passing unsatisfactory grade (62) for the first semester.

Of sixteen students failing to obtain a grade of 50 per cent in aptitude and chemical information tests, four were not admitted, one left shortly after admission due to sickness. Of the others completing the semester's work, two failed, one received a condition grade, five received low, unsatisfactory grades (74, 74, 76) where the C limit was 70–79 and the average semester grade was 72.3. Further evidence is presented regarding the results of students obtaining high and average placement test records.

THE USE OF BIOGRAPHY IN SCIENCE*

Shall we teach biography in science classes? If so, where will we find the material to teach and how shall we teach it? It is not the intention to give a full consideration or final solution to these problems but merely to open a discussion.

We are all aware that science is growing rapidly. Professor Hildebrand stated at the Los Angeles meeting of the A. C. S. in August, 1925, that "the new chemical discoveries in the United States alone require 10,000 printed pages of report yearly." Rapid advances are also being made in other fields of science and in nearly every part of the world. Such subjects as atomic structure, radio-activity, organic chemistry, radio, etc., cannot be disregarded in our courses. However, the capacity of students is not increasing to meet these advances since, with compulsory education, we are getting all children instead of just the brighter ones.

Considering this, can we take time from teaching the facts and principles of science to teach biography? Science does not consist of subject-matter alone but involves method, a way of tackling a problem. Powers[1] has

* An abstract of a paper read by Edna R. Bishop before the National Science Section of the California Teachers' Assoc. at Fresno, November 24, 1925.

[1] "How Long Do Students Retain What They Have Learned from High-School Chemistry?" THIS JOURNAL, **2**, 174–80 (1925).

shown that much of the subject-matter of high-school chemistry is quickly forgotten. That method is the more important item is shown by the emphasis that was placed on it at the Los Angeles meeting of the A. C. S.[2] and elsewhere. Not only is the study of biography a valuable means of learning method, but it will also add human interest, romance, and inspiration to any course in science.

Where may this material be found? Text-books give very little information along this line. Encyclopedias are little better. Sanford[3] stresses the importance of reading original descriptions by the investigators themselves and suggests Tyndall's "Sound" or "Heat" and Faraday's "Experimental Researches in Electricity." However, very little original work is in such form that it is usable for high-school students. The following sources of material are mentioned: Harrow, "Eminent Chemists of Our Day"—Van Nostrand; Gregory, "Discovery, The Spirit and Service of Science"—MacMillan; Vallery-Radot, "The Life of Pasteur"—Doubleday Page & Co. Popular magazines often contain good material in very readable form. "The Almighty Atom" by Roberts[4] is cited.

It would not be feasible to put very much, if any, of this material in the hands of all our students. Everyone, however, may read about at least one scientist and the class may receive benefit through a special report. The difficulty here would be in getting reports which would bring out the information desired instead of merely encyclopedic data which would not develop intelligent listening on the part of the class. This difficulty may be greatly decreased by conferences with each pupil before the report is given and by following the report with a class discussion in which the important items are emphasized.

W. R. W.

[2] Symposium: "What Are Our Objectives in Teaching Chemistry?" THIS JOURNAL, **2**, 971–97 (1925).

[3] Sanford, "How to Study, Illustrated through Physics," MacMillan Co.

[4] *World's Work*, **50**, 414-23 (1925); (Abstract, THIS JOURNAL, **2**, 938 (1925).)

NEW ELEMENT DISCOVERED

As this number of THIS JOURNAL goes to press, the newspapers are announcing to the world the discovery of the hitherto "missing" element, number 61, by Dr. B. S. Hopkins and his associates of the University of Illinois. The new element is to be named Illinium in honor of its place of discovery. This is the first of the elements to be discovered in America by an American. THIS JOURNAL takes particular pleasure in congratulating one of its contributing editors upon the successful completion of such an important project.

ABSTRACTS

Activated Sludge Sewage Treatment Solves Difficulties. WELLINGTON DONALDSON. *Nation's Health* **8,** 1–3 (1926).—The sewage of small seacoast communities often produces offensive pollution of water adjacent to residences and bathing beaches, if the discharge vent is close to the shore line. In many cases transportation of sewage to deep water is impractical. At Mamaroneck, N. Y., population 6000, the activated sludge treatment is used. Capacity of the plant is 1,000,000 gallons per day. The raw sewage flows through a series of open channels. Compressed air enters the bottoms of the troughs through small openings, the stream of effluent sludge being agitated and brought into intimate contact with oxygen by this method. Aeration proceeds for five hours, being followed by settling. The treated sewage then separates by gravity into a colorless clear liquid, and an inoffensive flocculent solid or sludge. The latter may be used as fertilizer. The process is both biological and chemical in nature. Portions of the "activated" or finished sludge are added to the incoming sewage to "inoculate" it, and speed up the process of transformation. The author gives cost data.
V. R. THAYER

Commercial Production of Radium, Mesothorium, and Helium. R. B. MOORE. *Ind. Eng. Chem.* **18,** 198–211 (1926).—Crude mixtures of barium and radium salts are obtained from uranium ores by treatment with any of several reagents, including conc. and dil. H_2SO_4, conc. and dil. HCl, conc. and dil. HNO_3, and Na_2CO_3. Refractory compounds are fused with $NaHSO_4$ and NaCl. Low-grade ores are concentrated by "sliming" and filtering, since most of the radium is contained in the fine particles. The article gives a detailed description of each method, discussing the ores best suited for the various processes. The crude salts obtained are converted to chlorides, and later to bromides, or in some cases to bromides directly. The latter are preferable for refining because they exhibit a greater difference in solubility between the barium salt and the radium salt, a lesser number of fractionations being required to separate the latter. Estimated total production of radium to date is 300 grams, calculated as element. Cost of production from an ore body recently mined was about $40,000 per gram. Mesothorium, replacing radium in some industrial applications, saves the latter for medical uses. Use of a non-flammable gas by the Germans for military balloons in 1914, stimulated interest in commercial production of helium. Improvement in the processes for recovery of helium from natural gas by liquefaction and fractional distillation, has reduced the production cost from $400 to $30 per 1000 cubic feet. Capacity of the present plant at Fort Worth, Texas, is about 1,300,000 cubic feet per year. The article gives in detail, history of the development of the process, and description of plants for recovery and repurification, with diagrams. List of the previous Perkin medalists, with their contributions, is given.
V. R. THAYER

Report of Surgeon General's Committee on Tetraethyl Lead. W. H. HOWELL. *Ind. Eng. Chem.* **18,** 193–6 (1926).—The sale of ethyl gasoline, tetraethyl lead, was voluntarily discontinued on May 5, 1925, following the occurrence of poisoning among workmen engaged in the manufacture of the latter compound. Soon thereafter a committee appointed by the Surgeon General of the United States began an investigation to determine whether use of such motor fuel, under practical conditions, was dangerous to health. Since certain retailers in Dayton and Cincinnatti, Ohio, had sold ethyl gasoline for about two years previously, and continued to do so after the wholesale distribution ceased, the investigation was conducted in these cities. Two hundred and fifty-two men, including automobile drivers, garage workmen, and employees in certain other industries, were used as subjects in the tests. Part of this number were drivers and handlers of gasoline, who were not exposed in any way to tetraethyl lead, being used as control groups. The maximum concentration of the lead compound in the fuel was $^1/_{1300}$ by volume. Three distinct tests were used: chemical examination of the feces for lead, count of stippled corpuscles in samples of blood, and clinical examination for symptons of lead poisoning. The third method gave no positive results. The data secured were interpreted as follows: (1) Drivers of cars using ethyl gasoline showed no abnormal effects as compared with the control group of drivers, and with employees in the Public Health laboratory. (2) Garage workmen in both control and test groups exhibited greater accumulation of lead than drivers. Those employed in shops using leaded gasoline were affected slightly more than the others. (3) Workmen in various industrial plants where the lead dust hazards are admittedly high, showed several times the amount of leading found in any of the employees in automobile work, although the former group was exposed a lesser time. The committee concludes that present knowledge does not warrant prohibition of the manufacture of

ethyl gasoline, and recommends that further investigation be conducted by the Surgeon General, to study other health hazards of the automobile industry in general, and to consider more individuals, longer time of exposure, and more widespread use of the compound, before deciding definitely the status of tetraethyl lead.

V. R. THAYER

The Humanity of Chemical Warfare. H. L. GILCHRIST. *Military Surgeon*, **57**, 529–38 (1925).—The writer of this article has spent some time in ascertaining the knowledge of the general public on chemical warfare. His test shows everywhere a lack of accurate information regarding the facts. The purpose of the article is to lay before the reader facts supported by official statistics.

Data given were obtained by a careful examination of the official reports of the Surgeon General of the Army pertaining to the casualties resulting from the war; an analysis of the casualty reports of foreign countries whose armies participated in the war; information obtained from physicians and others who were not only familiar with warfare gases as used in France but who had had experience in treating cases supposed to be suffering from their remote effects; views of manufacturing chemists of this country on the subject; and a series of experiments at the Medical Research Laboratories at Edgewood Arsenal, Maryland, on animals exposed to gases such as were used in the late war, at different concentrations and for varying periods of time. The conclusions reached are:

(1) The humanity of any war weapon can only be gaged by the amount of suffering caused by that weapon at the time of injury, the degree of permanent disability and the remote effects, if any, resulting from wounds produced by the weapon.

(2) During the past war there were 72,552 casualties from gas in our army. Of this number 200 died on the field of battle and 1221 died in the hospitals from the effects of gas exposure giving a mortality of 2 per cent. There were 187,586 casualties from weapons other than gas. Of this number 46,519 or 24 per cent died, making twelve times as many deaths from those weapons as there were from gas.

(3) There were 754 men blinded in one or both eyes from war weapons during the war. Of this number gas was responsible for 29 or 3.8 per cent, other weapons being responsible for 725 or 96.2 per cent.

(4) War weapons other than gas were responsible for 9147 permanently crippled soldiers. Gas was responsible for no permanently crippled.

(5) There were one and a half times as many cases of tuberculosis per thousand occurring among soldiers who were not gassed in France as there were among those gassed, apparently indicating that gas acted as a preventive against tuberculosis.

(6) As a result of extensive correspondence with over 3000 physicians in this country and Europe familiar with gases, with chemical manufacturers who have long produced gases similar to those used in the war, from a careful study of the records in the Veterans' Bureau, veteran hospitals, and from continued laboratory research conducted at the Medical Research Division, Edgewood Arsenal, we are led to believe that in a great majority of instances persons suffering from exposure to lethal concentrations of gases show no permanent resulting pathological lesions. It is true in a minority of instances some permanent damage is done, but the damage is not widespread and is generally confined to small areas with the formation of fibrous tissue which is so small in amount as to hardly affect the functional efficiency of the lungs.

(7) From an exhaustive study of this entire subject during which every effort was made to ascertain the true facts concerning the immediate and remote effects of the different warfare gases, the amount of suffering produced by each at time of exposure, and the percentage of deaths occurring among gas wounded as compared with the deaths resulting from wounds produced by other war weapons, it can be safely said that the use of chemicals in warfare is the most humane of any of the recognized weapons.

W. R. W.

Dyeing Artificial Silk. ANON. *Dyestuffs* **26**, 180 (1925).—One of the causes of unevenness in dyeing of artificial silk is due to the irregularity in the composition of the fiber. Direct dyes may be used on viscose. Basic dyes are also extensively used but must be mordanted with tannic acid and fixed with tartar emetic. Sulfur dyes may be utilized on viscose in the same manner as cotton.

T. G. T.

A Plan for the Use of Coöperative Tests. ANNETTE BENNETT. *Educ.* **46**, 27 (1926).—Schools and classes should be more standardized and classified. Emphasis should be placed on tests given every week and reclassification should be made every five weeks.

T. G. T.

The Effect of the Summer Vacation on Children's Mental Ability and on Their Retention of Arithmetic and Reading. M. V. W. PATTERSON. *Educ.* **46**, 222 (1926).—

Decided loss during the summer occurred in arithmetical achievement. Advocates a drill or repetition of fundamentals early in fall term. T. G. T.

The Problem of Science Teaching in the Secondary Schools. R. A. MILLIKAN. *Sch. Sci. Math.*, **25**, 966–75 (1925).—The writer quotes Pasteur, H. G. Wells, Herbert Spencer, and the General Education Board to show the importance of the development of science and the scientific method, and then sets down five conclusions in which the problem is divided into three elements or parts: first, the method or technic; second, organization of the curriculum and opportunity and urge given the student to secure the science courses he needs; and third, the provision of suitable teachers.

The technic of teaching high-school physics, at least, is pretty well-known, and the author believes that most of the other high-school sciences may be classed with physics. Until organization of the curriculum and provision of suitable teachers has been more thoroughly worked out, further time spent on it is almost useless. Secondary school teachers for the past fifty years have been working out this technic for themselves until there is now a general agreement on the subject—it has not been obtained from courses in schools of education or teachers' colleges "for the very obvious reasons, first, that these courses are rarely taught by men who know by actual experience much about secondary-school science teaching; and second, that such courses lack the most vital and essential element of high-school teaching, namely, learning by doing, contact with the presentation of the subject-matter itself."

In an article published in the January issue, 1916, of *School Science and Society*, the writer showed that "our whole energies, therefore, ought to be directed to the arrangement of the curriculum so that we can get as many of the pupils as possible to take three consecutive years of science" and "that the place of general science is in the grades." "The exigencies of a high-school curriculum do not permit it to be an introduction to a three-year course in the special sciences." From the article, "The Changes in Science Enrolment in Minnesota for the Five-Year Period from 1915 to 1920" by W. R. Leker in *Sch. Sci. and Math.*, **25**, 730 (1925), the author quotes the following changes in percentage of total enrolment from 1915 to 1920:

Gen. Sci.	1.2 to 11.5%	a gain of 858%
Physics	10 to 7.8%	a loss of 22%
Chem.	11 to 9.7%	a loss of 12%
Biol.	1.7 to 1.8%	a gain of 6%
Zoöl.	6 to 2.9%	a loss of 51%
Bot.	10 to 6.2%	a loss of 38%
Physiol.	7.5 to 6.3%	a loss of 16%
Totals	47.4 to 46.2%	

and concludes—"General science has made its large percentage gain of 858% wholly at the expense of the individual sciences" and also reaches the further conclusion, in opposition to Mr. Leker's, that "general science in the high school should never be a course required of all pupils."

The third element of the problem; the provision of suitable teachers, teachers who have gotten into contact with science itself and practiced using it, is the duty of the graduate schools of science. "At present, administrative restrictions and pedagogic requirements, (in Calif.) whatever their intent, tend to divert the best trained and best qualified young men away from the secondary school." An amelioration of entrance conditions for teachers with outstanding qualifications in science, with subsequent courses in educational psychology, and like courses, if deemed necessary, is suggested as the part of wisdom. B. H. B.

Types of Tests Desirable for Chemistry and the Present Status of Their Development. HENRY L. GERRY. *Sch. Sci. Math.*, **25**, 918–22 (1925).—Of the many kinds of tests needed in chemistry a few that seem especially to be demanded are: General survey tests, both to determine the status of groups of students in different stages of advancement, and by a series of more extensive tests than the group test to get an objective, quantitative measure of the individual's achievement.

Tests of a more specific nature; including prognostic tests to determine in advance the student's chance of success, and thus eliminate the present tremendous waste of time and money due to the failure of those unable to do the work; tests to determine the status of an individual at the beginning of a course, one kind which by repetition later on would show the advancement in the strictly scientific aspects of the subject, and a second kind to determine the individual's background against which the scientific study can be projected; diagnostic tests to locate the student's particular difficulty; intensive tests over the constituent parts of the whole course, such as the mathematics

of chemistry; tests on the smaller units in the usual organization of the subject, such as oxygen; and tests to determine what the student can do in addition to above tests on what he knows, such as use of familiar material in new situations, laboratory skill, etc.

Writer observes that relatively few attempts have been made to construct such tests, and these are acknowledged to be crude and unfinished, but it is hoped that they will lead to more adequate measuring instruments. A partial bibliography is published.

B. H. B.

Some Psychological Experiments. J. MCKEEN CATTELL. *Science*, **43**, 1–8, 29–35 (1926).—An excellent review of the development and use of methods for measuring individual differences by means of mental tests. Numerous examples are given of reaction time to stimuli of different kinds and complexity. The success of the methods of selection used in the conscripted army is cited in proof of the statement that this world would be immeasurably benefitted if these findings were used to select the man for the work.

In regard to the application of psychological methods to students, the author recommends the use of the age curve to determine at what time certain subjects should be presented to primary school pupils. For college students a system of grading is recommended which not only would give extra credit for good work but would make the good student pay a lower fee. Normal individuals differ from each other in a ratio of about 2 to 1.

A quantitative basis of numerical grading is suggested in which a grade of sixty means that in one hundred students there are about forty better and fifty-nine not so good as the person graded sixty.

G. H. W.

Gilbert N. Lewis, Scientist. ANON. *Nebraska Alumnus*, **22**, 16 (1926).—The subject is sketched as a brilliant and distinguished scientist as well as a man in public affairs, an author of articles upon physics, mathematics, and economics as well as of books in physical chemistry. His college and university connections extend from the University of Nebraska to Harvard, German Universities, Massachusetts Institute of Technology, and University of California. In less academic fields his activities have taken him to the Philippines as Superintendent of Weights and Measures and to France where he became American Chief of the Training Division of the Gas Service. His greatest contributions have been made in the field of thermodynamics although he has made notable contributions to the literature treating of the structure of matter.

B. C. H.

The Exceptional Student in the Middle West. J. A. RICE. *Bull. Am. Assoc. Univ. Prof.*, **11**, 453 (1925).—The paper represents extracts from an address made at the Conference on Honors at the University of Iowa last spring. Our failures in meeting the needs of the College of Arts student of superior ability are summarized by Doctor Rice as: no contact with his teachers, especially outside the class-room; a "labyrinth" substituted for a curriculum; a standard founded upon mediocrity rather than excellence; no recognition for superior achievement and an undue emphasis upon "amassing credits" rather than upon content of a subject or subjects which are of interest to the student.

B. C. H.

Scientific Men as University Presidents. EDITORIAL. *Bull. Am. Assoc. Univ. Prof.*, **11**, 466 (1925).—"It is gratifying to note that two of the great universities, Michigan and Chicago, have chosen as presidents men of exact scholarship." The two men referred to are: Doctor Clarence C. Little, new president of the University of Michigan and Doctor Max Mason of the University of Chicago. In commenting upon the desirability of scholarship as a qualification for such a position, as well as administrative ability, the statement is made that scholarship enables its possessor "to appreciate the problems in every sector (of human knowledge) for the method of advance must be the same whether one uses a microscope, a telescope, a retort, a syllogism or an algebraic equation."

B. C. H.

Inspection Trips for Chemical Engineering Students. CHAS. A. MANN. *Chem. Bull.*, **13**, 4 (1926).—Some objections to such trips are: expense to students, time lost by student while upon the trip, interference with the normal operation of the plant visited, danger from accidents, and possibility of the industry losing some of its trade secrets. Disadvantages notwithstanding, the author sees many advantages of these trips to both students and to the industry. To the former, these trips exhibit: equipment in operation, the relation of successive equipment pieces to a given process, the use of research and control in plant operation and a demonstration of the need of business methods in directing the whole. To the industry there are the advantages of: publicity and advertising, cultivating new patrons among the visiting students and attracting worthwhile employees from these student visitors. A necessary requirement for

making the most of one of these trips is the obtaining of intelligent, technically trained guides during the visit. Some things these guides should bear in mind as of special interest to the visiting students are enumerated. "Here is a real chance of coöperation between industry and the university." B. C. H.

Some Daily Helps for Paracelsus from Lavoisier. K. LUCILLE MCCLUSKY. *Chem. Bull.*, **13**, 3 (1926).—Paracelus said, "The true purpose of chemistry is not to make gold but to prepare medicines." This purpose is being realized to some extent. The chemist is having his turn in helping to solve the physician's problems of prevention, diagnosis, and treatment. The last problem, treatment of disease, is the phase of medical assistance rendered by chemistry, commonly thought of by those who think of any relationship whatever. The author seeks, however, to direct attention to the role of the chemist as a diagnostician as well as synthesizer of medicines. Diagnosis and treatment are commonly based upon clinical data, but it is becoming increasingly more the practice to use the findings of the chemist. Examples cited are: chemical examinations to direct pre-operative and post-operative treatments, chemical tests to distinguish between acidosis and alkalosis, chemical laboratory tests to follow and prescribe for diabetes and to control insulin administration, and blood analysis in prescribing for gastro-intestinal obstructions. In general it is suggested, "Chemistry .....makes possible a better diagnosis, a saner treatment and a safer prognosis of disease." B. C. H.

Atomic Theory and Mechanics. N. BOHR. *Nature*, **116**, 845–52 (1925).—An address delivered before the Scandinavian Mathematical Congress in Copenhagen. A historical, non-mathematical treatment of an extremely popular and important subject. H. K. M.

The Occurrence of Dwi-manganese (At. No. 75) in Manganese Salts. A. N. CAMPBELL. *Nature*, **116**, 866 (1925).—C. does not think Dolejšek and Heyrovský (THIS JOURNAL, **3**, 231 (1926)) are justified in their deductions from the potential-current curves. The second hump in the curve might represent the potential of incipient hydrogen discharge. C. would like to know the form of current-potential curve at the same electrode in an electrolyte containing no manganese and also the effect of superposing an alternating current on the direct. H. K. M.

Atoms and X-Rays. F. W. ASTON. *Nature*, **116**, 902–4 (1925).—In a presidential address delivered before the Röntgen Society, A. calls to mind the early theories of Prout and Dalton and how chemists, forced to choose between the two theories, chose the one that was untrue. In this they were perfectly right for it is more important that a scientific theory should be simple than that it should be true. Then follows a resumé of the work on isotopes and ionization with a table of the isotopic analysis of the fifty-six elements that have been studied. The various claims of artificial transmutation are discussed and in particular the work of Rutherford and the striking confirmation by Blackett who, using the beautiful Wilson fog-track method, has actually succeeded in photographing the disintegration of nitrogen nuclei struck by swift alpha particles. Eight disintegrations were detected in the 400,000 tracks photographed. The thin track of the dislodged proton could be clearly seen and a somewhat unexpected feature brought out is that in each case the projectile is retained by the target. The nitrogen nucleus loses a proton but captures the helium nucleus fired at it and so would seem to become an isotope of oxygen of at. wt. 17. No such body is known which suggests that the atom so formed is not stable. The article closes with a brief discussion of atomic energy and a few speculations. H. K. M.

The Training of Teachers. M. W. KEATINGS. *J. Ed. and Sch. World*, **58**, 32–6 (1926).—K. comments on the paper by Malim (THIS JOURNAL, **2**, 1201 (1925)) under same title and outlines what Oxford is trying to do for its 140 students studying education. H. K. M.

A Scheme of Objective Marking. C. R. DUSTIN. *Educ. Res. Bull.*, **5**, 28–33 (1926).—The system of marking described in this article resulted from an attempt to provide more impersonal and objective methods for determining achievement than were possible under any former system. The system requires (1) that the mark which is given for scholarship be based upon achievement alone; (2) that a uniform distribution be arranged for the school; (3) that in each subject the pupils be grouped so as to approximate this distribution; (4) that marks assigned will approximate the distribution; and (5) that ability tests be given to all pupils to determine their probable learning rates.

The first requirement, that the scholarship mark be based only upon achievement, makes necessary the preparation of a series of tests in each subject and the ranking of pupils according to the scores which they make on these tests. A test is made purely

objective by constructing a scoring key before the test is given. Each pupil was assigned to some one of ten groups depending upon his score. The only mark for each test which is recorded in the teacher's class book is the group rank made on that test. One test is given each week of the marking period. These tests cover the work of that week and any previous work needing to be reviewed. Tables are given to illustrate the method employed in determining each pupil's position for the entire marking period. His final rank is the sum of his positions on all the tests he has taken.

Such a system of marking is relative, since it provides for the marking of pupils in terms of the achievement of the class rather than on an artificial standard set up by the instructor. Effort is regarded as the relationship between a pupil's achievement mark in a given subject, and his ability to do school work as indicated by his probable learning rate determined from three intelligence tests.

There are several possible shortcomings of this system. It is assumed that the probable learning rate is a measure of capacity, but we are not certain to what extent it may become a measure of achievement. The distributions were selected for practical rather than scientific reasons. Experience, together with the adaptation of the course of study better to meet the requirements of individual differences, may demand a change in the distributions which have been accepted. It is also necessary to base the determination of effort marks upon certain assumptions until experience may reveal a more reliable basis for their computation. Whatever may be its shortcomings, the system is an attempt to make all marking objective, for achievement marks are given according to the mastery of subject-matter. W. R. W.

A New Method for the Determination of the Molecular Weight of the Proteins. THE SVEDBERG AND R. FAHRAEUS. *J. A. C. S.*, **48**, 430–9 (1926).—As a result of recent researches on the proteins, the tendency seems to be to assign to them molecular weights considerably higher than the older values arrived at from the metal-protein ratio. This is shown in the recent work of Dr. Cohn who arrived at his much higher values through a study of the viscosity of protein solutions and in the work here reported. The authors have worked out a new method based upon the measurement of sedimentation equilibrium in a protein solution exposed to a centrifugal force. They derive a formula which is found to hold well for dilute solutions. A small quantity of the solution to be studied, from 0.01 to 0.25 cc. is enclosed in a glass or quartz cell possessing plane parallel walls and rotated at constant temperature in a special centrifuge which permits photographing the solution when exposed to a centrifugal force up to 5000 times the force of gravity. Then, in the same cell, are photographed solutions of different concentrations shortly after the centrifuge is started and before sedimentation has begun. A curve may then be drawn giving the relation between the concentration and the distance from the center of rotation. The apparatus is described and several tables of results are given. As an illustration of results obtained, the value for the molecular weight of hemoglobin in aqueous solution is probably 66,800 or four times the older value. A. P. B.

The Smithsonian Institution, Its Function and Its Future. AUSTIN H. CLARK. *Science*, **63**, 147–57 (1926).—The Smithsonian Institution is not of national origin but was the establishment of an individual, James Smithson, an Englishman, who never saw America. The institution is the trustee of his fortune which is to be used for "the increase and diffusion of knowledge among men."

Problems in all branches of science are investigated without regard to apparent economic importance. No activity is undertaken that is being carried on by other institutions. The activity of the society is discussed under the following heads: Activities, Past and Present; Needs in Science Which the Smithsonian Institution Proposes to Meet; Studies on the Sun; Studies on the Sea; Studies on Insects; Studies on Fossils; Studies in Anthropology and Archaeology; Research in Animal Diseases; Studies on Plants; Research Assistants; Explorations; Publications; The Future. G. H. W.

Guggenheim Fund for Aeronautics. EDITORIAL. *Science*, **63**, 159 (1926).—The Daniel Guggenheim fund for the promotion of aeronautics will spend $2,500,000. to foster aeronautic science in the next ten years. It is proposed to establish chairs of aeronautics in universities of the West, South, and Southwest. Guggenheim has already given one-half million dollars to New York University for an aeronautical school and the Boston School of Technology already has such a course. The needs of the East in this line are deemed to be met. G. H. W.

Plans for the Development of the Department of Chemistry at the University of Chicago. EDITORIAL. *Science*, **63**, 64 (1926).—A citizen's committee on chemistry, in coöperation with the University, will undertake to raise a fund of $3,235,000 for a

new laboratory building and the endowment of instruction and research in chemistry. The committee is made up of twenty-six of Chicago's prominent business men.

G. H. W.

The Relative Efficiency of Pyrex Glass and Metal Condenser Tubes. J. T. LITTLETON, JR., AND H. C. BATES. *Am. Inst. Chem. Eng.*, preprint, Dec., 1925.—The resistance of the surface film on bright copper, oxidized copper, Shelby steel, and Pyrex glass condenser tubes determines their efficiency. The volume conductivity of the different materials has little effect on the condensing power, for copper with 6 times the conductivity of steel condenses only 10% more steam. An oxidized copper tube, however, will condense less steam than a steel tube. Copper with a conductivity coefficient 300 times that of Pyrex glass condenses only 2.5 times as much steam. G. B. HEISIG

UNITED STATES CIVIL SERVICE EXAMINATION FOR JUNIOR CHEMICAL ENGINEER

Receipt of applications for junior chemical engineer will close April 17th. The date for assembling of competitors will be stated on the admission cards sent applicants after the close of receipt of applications.

The examination is to fill vacancies in various branches of the Government service throughout the United States.

The entrance salary in the District of Columbia is $1860 a year. After the probationary period required by the civil service act and rules, advancement in pay may be without change in assignment up to $2400 a year. For appointment outside of Washington, D. C., the rates will be approximately the same. Promotion to higher grades may be made in accordance with the civil service rules as vacancies occur.

The duties of this position are to perform such work as routine testing, making computations, assisting in conduct of experimental research tests, compiling reports, and handling technical correspondence.

Competitors will be rated on general physics; pure mathematics; and practical questions on chemical engineering, including applied mechanics.

Full information and application blanks may be obtained from the United States Civil Service Commission, Washington, D. C., or the secretary of the board of U. S. civil-service examiners at the post office or customhouse in any city.

Blue Vitriol Used for Burns. Blue vitriol, whose most common use is to supply the poisonous element in many spray mixtures for fruit trees, is now employed medicinally to treat phosphorous burns.

Burns caused by phosphorous are very painful and slow to heal because the cellular elements of the tissues with which the phosphorous comes in contact are destroyed, followed by the formation of ulcers and sores. Experiments conducted at the Medical Research Laboratory at Edgewood Arsenal show that 1 to 3 per cent of copper sulfate, otherwise known as blue vitriol, applied to a burn of this character will form a coating over the phosphorous ingrained in the tissues and render its removal easy. When the copper sulfate-coated phosphorous has been removed the wound is washed out and treated as any other burn.—*Science Service*

British and American Health Men Exchange. An international exchange of views and methods in public health work has been arranged for the benefit of British and American students, in an exchange of professorships between the London School of Hygiene and Tropical Medicine and the School of Hygiene and Public Health of the Johns Hopkins University. Dr. R. W. Hegner, professor of protozoölogy in the latter institution, expects to sail for England on March 31st, and Dr. J. G. Thomson will represent the London school at Baltimore. —*Science Service*

Local Activities and Opportunities

University of Nevada. A fellowship is offered by the University of Nevada in chemistry for 1926–27. This fellowship carries with it a stipend of $600.00 and freedom from tuition. The fellow will devote not more than half time (12½ hours per week) to instruction in the laboratory. The remaining time he will be expected to devote to advanced study and research. The fellowship is open to men and women who have had a thorough undergraduate training in chemistry and who hold a bachelor's degree from a college or university of recognized standing. Applicants should communicate with Professor Geo. W. Sears, Department of Chemistry, University of Nevada.

Washington, D. C., Section, A. C. S. The 375th meeting of the Washington Section of the A. C. S. was held at the Cosmos Club, February 11th. Dr. Paul D. Foote of the Bureau of Standards spoke on the "Possibilities for the Extension of the Present Theory of Atomic Structure to the Solid and Liquid Phases of Matter."

University of California. Dr. Gustav Egloff of the Universal Oil Products Company of Chicago recently presented an illustrated lecture before the Science Club of the University of California, Southern Branch, on the subject, "Recent Developments in the Production of Gasoline by the Cracking Process."

N. E. A. C. T. The New England Association of Chemistry Teachers held their 99th meeting, March 6th, at Brown University and will hold their 100th meeting, May 1st, at Boston College. A special program is being arranged for the meeting in May. It is believed that this is the only group of chemistry teachers which has held this number of meetings.

Municipal University of Akron, Akron, Ohio, announces Goodyear and Firestone Fellowships in Rubber Chemistry for 1926–27. These fellowships were established by the Goodyear Tire and Rubber Company and The Firestone Tire and Rubber Company for the encouragement of graduate research in the chemical problems connected with the rubber industry.

Each fellowship provides $1000.00 for the college year and is open to graduates from chemical courses of approved institutions.

The Municipal University will exempt the fellows from the payment of all fees, tuition, and breakage.

Any student to whom one of these fellowships is awarded will be required to do a maximum of nine hours per week of laboratory supervision and the remainder of his time must be devoted to research work. It is possible for a man holding one of these fellowships, by presenting a satisfactory thesis and passing examination, to secure the Master's degree at the close of the year.

Candidates for these fellowships should file their applications with the Director of the Knight Chemical Laboratory not later than April 1, 1926.

Application blanks may be obtained by addressing the same office.

Northwestern University, Evanston, Illinois. Twenty-seven graduate appointments, paying from five hundred to twelve hundred dollars, will be available for the academic year 1926–27.

Applications should be sent to Frank C. Whitmore, Chemistry Department, Northwestern University, Evanston, Illinois. Appointments will be made by March 31, 1926.

Each applicant should send (1) a complete transcript of his college and university record together with a brief de-

scription of the courses taken in chemistry, physics, mathematics, French and German, and (2) a recent photograph (passport type). He should also ask two of his professors to write directly to the chemistry department telling details of his qualifications and training which are not covered in his official transcript.

Fellowships. Sixteen Graduate Fellowships carrying stipends of from five hundred to eight hundred dollars are available. Holders of fellowships devote all their time to graduate work. Some of the fellowships are designated for research along special lines such as the Chemistry of Organic Arsenic and Organic Mercury which has received such splendid support from the Public Health Institute at Northwestern and Wisconsin in recent years. Others are without special designation.

Graduate Assistantships. Eight Graduate Assistantships are available. Graduate Assistants devote twelve hours per week during the academic year to duties connected with instruction and receive stipends of from five hundred to eight hundred dollars, depending on their training and experience. Graduate Assistants can register for three-quarters time in graduate work.

Chemists. The Intermediate Laboratory of the Public Health Institute located on the Campus employs a number of graduate chemists in synthetic organic work. These are half-time positions and carry stipends of from eight hundred to twelve hundred dollars. The holders can register for half-time graduate work.

Instructor. A part-time instructorship in elementary laboratory and quiz work will be open. The Instructor can register for half-time graduate work. The stipend is twelve hundred dollars. Applicants for this position should hold the Master's degree and should have had experience in teaching.

Fees. All new graduate students pay a matriculation fee of ten dollars. Fellows pay sixty-three dollars tuition. Assistants pay one hundred and twenty-five dollars tuition. All students pay for their breakage. Research chemicals are supplied.

University of Florida. The Florida Section, A. C. S., held its first 1926 meeting in Tampa on Feb. 6th. The program rendered was as follows:

"Councillor's Talk," Prof. A. P. Black, U. of Florida.

"Synthetic Methanol," Prof. R. S. Bly, Southern College, Lakeland.

"Pasteur as I Knew Him," Mr. Louis Parisot, Bartow.

"The Truth about Chemical Warfare," Prof. V. T. Jackson, U. of Florida.

The section adopted resolutions favoring chemical warfare as an efficient, necessary, and humane arm of our national defence; favoring the adoption of the metric system; and opposing a proposed amendment to the present copyright laws which would make it impossible to copyright mimeographed or multigraphed material.

Prof. A. P. Black, of the chemistry staff, addressed the Gainesville Sector, Reserve Officers' Association, at its February meeting. His subject was "Should Chemical Warfare Be Abolished?" The talk was illustrated by an extensive exhibit of chemical warfare materials furnished through the courtesy of Fourth Corps Area Headquarters.

Following out its policy of popularizing chemistry and its everyday applications, the department will begin at once the publication of a series of articles through the press of the state. This will be the second series published during the present school year.

Southwestern, "The College of the Mississippi Valley," opened in its new location at Memphis, Tenn., last September. One of the fine buildings in its new plant is the chemical laboratory. This was opened for work in January under the direction of Dr. William O. Swan. This laboratory cost upwards of $300,000 and is not only well planned and well equipped, but is a beautiful building as well.

Recent Books

College Chemistry. LYMAN C. NEWELL. D. C. Heath & Co., Boston, Mass., 1925. vi + 645 pp. 13.5 × 19.8 cm. $3.00.

"This book is based on the courses in general chemistry given by the author at Boston University during the last ten or more years. Throughout its preparation the need of the student has been kept constantly in mind, particularly his need of a book from which he can readily learn the fundamentals of chemistry. This thought has determined largely the style, arrangement and scope, especially in the first half of the book."

Students, especially those who have had no high-school chemistry, are likely to have difficulty with the first half of the book because of the concentration of theoretical matter, much of which might well have been left to a more advanced course. This is particularly true of some of the formulas, such as the equation for the kinetic-molecular theory of gases. The somewhat meager treatment of the chemistry of the metals comes as an anti-climax. A more balanced presentation would have seemed desirable.

A number of questionable points present themselves. Among these is the assumption that "nascent" oxygen causes the oxidizing action of hypochlorites, nitric acid, and several other substances. Is it not more reasonable to assume that oxidation is associated with a change in the valence of the chlorine or nitrogen? This would certainly be more in accord with the author's method of balancing equations by valence changes, and with his broad definition of oxidation. It is not clear what is meant by "chemical encounter of molecules" in explaining chemical equilibrium. The older ideas of differentiating between primary and secondary products of electrolysis is adhered to and unnecessary assumptions are made to explain the products of electrolytic decomposition. Some laws, such as that of Gay-Lussac, are not accurately stated.

The book contains much valuable information, interestingly presented. The style is clear and forceful and the entire format is commendable.

M. C. SNEED

Experiments in College Chemistry. LYMAN C. NEWELL. D. C. Heath and Co., Boston, Mass., 1925. vi + 320 pp. 111 figures. 13 × 19.7 cm. $1.60.

This book includes experiments for students who enter college either with or without credit in high-school chemistry. It contains 329 main experiments, many of which are followed by supplementary experiments, questions, and specific exercises. No single group of students will have the time to perform all these experiments, nor is it the intention of the author that they should be performed during any single course. The number has been made large "so that the college teacher can select an adequate number of experiments adapted to the preparation of students, to the time and equipment available and to the purpose of the course."

The book is an excellent one. The subject-matter is well chosen and well arranged. Lists of experiments are suggested in the appendix from which may be chosen those adapted to the preparation of students according to the "equipment of the laboratory and the scope of the course."

M. C. SNEED

Bacteriology. STANLEY THOMAS, M.S. and M.A., Associate Professor of Bacteriology, Lehigh University. First edition. Cloth. McGraw-Hill Book Co., New York, 1925. xiii + 201 pp. 23.5 × 15 cm. $2.50.

The writing of a text-book on bacteriology has become a very difficult matter because of the voluminous literature on the subject, and further, because there are still pronounced differences of opinion on many phases of the subject. The author of this volume has taken for his task the preparation of a general text to be employed in teaching elementary bacteriology to mixed classes of undergraduate engineers, chemists, pre-medical students, and general arts and science students. On the whole, the text covers this field very nicely. It should, therefore, make a definite place for itself.

The subject-matter is handled in twelve chapters, under the following captions: Introduction, History of Bacteriology, Classification of Bacteria, Morphology of Bacteria, Physiology of Bacteria, Bacterial Enzymes, Microörganisms other than Bacteria, Bacteria in Foods, Pathogenic Bacteria, Immunity, Hygiene and Sanitation, and Bacteria in Industry.

The manner of presentation is clear, and sometimes, possibly, a little too brief and concise. It would seem to the reviewer that certain topics should be supplemented by lectures. The sequence and pedagogic arrangement are somewhat unusual, but should prove excellent. The author has omitted the description of species and has not confused his text with laboratory directions, thus trying to cover the field of both text-book and laboratory manual. He has, however, used illustrations and references rather sparingly.

The introduction is intended to give a general

conception of life and life processes. It was written especially for those students who take an elementary course in bacteriology without having had any previous training in biology.

The author has employed the classification recently adopted by the American Bacteriological Association. He is to be commended for the manner in which he has handled this subject, in its present state. On the other hand, the reader is left somewhat in doubt as to the advisability of teaching this classification, at present, to students in elementary bacteriology unless they have had some grounding at least in laboratory work.

The chapters on Bacterial Enzymes, Hygiene and Sanitation, and Bacteria in Relation to Industry are especially good. The index is also generally complete.

A word should be said in commendation of the publishers in their preparation of this book. It is printed on a good quality of heavy paper, in very clear type, and is well bound.

E. M. PICKENS

Chemistry, Including Recent Examination Questions. M. H. KESSEL. Globe Book Company, New York, 1925. 112 pp. 15.5 × 22.5 cm. $0.67.

This little book, written for "students preparing for examinations in chemistry" gives a summary of the information that a student might be expected to have at the end of his high-school chemistry course.

The principal chemical laws and theories are listed, a considerable number of problems in chemical arithmetic are given, short laboratory experiments are described and apparatus pictured and the occurrence, preparation and properties of the more important elements and compounds are mentioned. Besides these, a few qualitative tests are described. At the end of the book are sets of typical examination questions which might be of value as a guide in review. Since all this is done in about a hundred pages, statements are necessarily concise and in but little detail.

Some question might be raised as to the treatment given molecular weights and weight of a liter of gas *via* vapor density, electrolysis of brine, nascent oxygen and the avoidance of more discussion of the ionic theory, but in its place the book can serve and no doubt will. For review and preparation for examinations, it ought to be valuable.

THOMAS B. BRIGHTON

Chemistry and Civilization. ALLERTON CUSHMAN, A.M., PH.D. Director of Industrial Research, Washington, D. C. New and revised edition. E. P. Dutton, New York, 1925. ix + 167 pages. 6 illustrations. 15 × 21 cm. $2.50.

"Chemistry in the service of man is the author's theme in this volume, founded upon the series of lectures delivered by him at the Wagner Institute of Science, Philadelphia, under the Richard B. Westbrook Lectureship Foundation."

The method of presentation is largely historical and the book first discusses cosmic chemistry and the advances made by man as he progressed in civilization. The works of the alchemists and phlogistonists are reviewed and then the discoveries of Lavoisier, Davy, Faraday, Liebig, and Pasteur, are presented in a popular way.

The application of chemistry to the basic industries and the rise of organic chemistry is treated in an entertaining manner. The subject of nitrogen fixation has been brought up to date and in this connection the topic, "Chemistry and War," receives adequate treatment.

The last three chapters deal with "Chemistry and the Future." The discovery of X-rays and radio-activity is first discussed and then the author outlines some of the conclusions which can be drawn from these facts. A simple and readable outline of the Einstein theory is included. The subject of colloids and dispersoids is next introduced and a brief treatment of the theories of solutions follows. The story of helium is related in a very interesting way and the author makes some predictions as to the future progress of the race.

The final chapter tells about the modern concepts of matter and energy. After an historical introduction the modern views are simply and clearly stated and the book ends with some predictions concerning the modern transmutation of metals.

Modern life demands some popular knowledge of chemistry and this book is one of a group that will aid the lay reader to understand why chemistry is necessary for liberal culture. All chemistry teachers should attempt to "humanize knowledge" and this book is distinctly valuable for this purpose. Technical details are necessary for the scientist but all others should be given an opportunity to realize the relationship of "Chemistry and Civilization."

R. N. MAXSON

The Use of Solvents in Synthetic Organic Chemistry. DONALD W. MACARDLE, S.B., Asst. Prof., Boston University. Vol. I. D. Van Nostrand Co., New York, 1925. vii + 217. 15 × 23 cm. $3.50 net.

The author states in his preface, "This volume is planned as the first part of a treatise on the operative technic of synthetic organic chemistry, similar in a general way to the first sections of the well-known German works of Lassar-Cohn and of Weyl."

There is no question but what such a series of books written in English and brought up to date will be of genuine value, not only to the research and university worker, but also to the industrialist. The author has the reviewer's respect and admiration for attempting a piece of work of such magnitude, and he should be

congratulated for the very successful manner in which he has written this first volume.

The book contains, first of all, a chapter on general considerations, which include the theory of solution. This chapter could hardly be improved upon with the possible exception of more material regarding the use of the polarity factor in predicating solubilities as outlined by Joel H. Hildebrand. This chapter is followed by a chapter covering the use of different types of organic solvents, such as alcohol, ethers, acids, esters ketones, and hydrocarbons. There are two final chapters; one on special means of inducing crystallization, and another on "salting out." The chapter on crystallization is especially good and is undoubtedly the best summary of methods written in English.

In order to get an idea of the magnitude of this work, it should be noted that there are over 900 references. Each reference has been gone over by the author and he has made an excellent abstract of each, the summation of which comprises the body of the book.

It will be impossible to give in a short space the many different references which seemed of special interest. It should be stated, however, that the reviewer found many references that will be of particular value to him in his own line of work. The book is not written from a critical standpoint, and though it is realized that a critical review would be almost impossible, nevertheless the value of such a review would be enormous. The author, furthermore, has confined himself to an academic viewpoint and has not attempted to follow up the use of solvents in industrial synthetic operations. This is perhaps not necessary, but it would, however, in the reviewer's opinion, add to the value of the treatise as a textbook.

One amusing instance where the writer failed to appreciate the significance of industrial processes was noted in his chapter on the preparation of absolute ethyl alcohol. There is probably no modern development in solvent manufacture that has meant more than the manufacture on an industrial scale of absolute ethyl alcohol. The author gives twenty-five pages of subject-matter on the laboratory preparation of absolute alcohol while he allows only four lines to the only successful process for the manufacture of this solvent. Furthermore, he gives credit for the invention of this process to an English patent attorney who was acting for one of the American inventors.

The reviewer was especially interested in the apparent lack of use of anhydrous esters as solvents; for example, anhydrous ethyl acetate. This is probably due to the fact that an anhydrous ethyl acetate practically free from alcohol has been a commercial product for only a few years. It would seem to the reviewer that research on the use of this new solvent might lead to interesting results.

D. B. KEYES

Fundamental Concepts of Physics. PAUL R. HEYL. The Williams & Wilkins Co., Baltimore, 1926. xii + 112 pp. 12.5 × 18.5 cms. $2.00.

In three lectures the author discusses the changes in the scientific conceptions of physical phenomena, presenting clearly and lucidly the fundamental factors that led to the revised concepts for each century from the eighteenth to the present.

In the scientific world of the eighteenth century there were three predominant characteristics. (1) an extremely materialistic interpretation of physical and chemical phenomena, (2) an inconsistent tendency to resort to supernatural explanations, (3) a failure to lay emphasis on quantitative data. Science was a study of matter only; matter as a hard, heavy, ultimate substance. Gravitational, mechanical, electrical, and magnetic forces were known, but were regarded as properties of matter. The "imponderables" were introduced, resulting in such theories as the caloric, the corpuscular, the electric fluids, the magnetic fluid. The exception to this materialism was the "vital force," which supposedly resided in all organic matter and controlled all organic reactions.

The nineteenth century was one of correlation. The isolated and distinct concepts of matter, heat, light, electricity, magnetism, and the various forces, handed down from the previous century were correlated—all except that of gravitation—into two, the concept of matter, materialistic, and of energy, immaterial, yet always associated with matter. This latter association necessitated the postulation of a new "imponderable," the ether of space, to explain the apparent existence of light energy in space empty of matter as usually conceived. The law of the conservation of energy was advanced, complementary to that of the conservation of matter.

The twentieth century has furnished a correlation between electricity and matter—matter is merely an electrical phenomenon, and the doctrine of the inertia of energy—matter and energy are not independent entities, but are aspects of inertia; matter, static; energy, kinetic. The assumption of the quantum concept that energy is discontinuous in its nature seems justified by its various successful applications. The relativity theory unites the concepts of gravitation and inertia, hitherto the defining properties of matter, by advancing the concept of curved space. "Matter is a static curvature in space. . .; if the static becomes kinetic, matter becomes radiant energy."

The book is very readable, easily understood, written in a semi-popular style. It is well worth reading for everyone interested in science, especially for the discussions of the "dissipation of energy," the quantum theory, and relativity in general.

C. G. EICHLIN

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Sept. 1, 1924—Dec. 31, 1925, inclusive

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Signed, EMMETT E. DEAN
FRED'K H. GARDNER
Auditors